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I. ON THE SPECTRAL PHENOMENA OF OPALS.

By WILLIAM CROOKES, F.R.S., &c.

A FEW months ago* the writer described a new form of spectrum microscope, in which some of the disadvantages possessed by the old form are removed. The new spectrum apparatus consists of two parts, which are readily attached to an ordinary single or binocular microscope, and when attached they can be thrown in or out of adjustment by a touch of the finger, and may readily be used in conjunction with the polariscope or dichroscope; object-glasses of high or low power can be used, although the appearances are more striking with a power of $\frac{1}{2}$ -inch focus or longer; and an object as small as a single corpuscle of blood can be examined, and its spectrum observed.

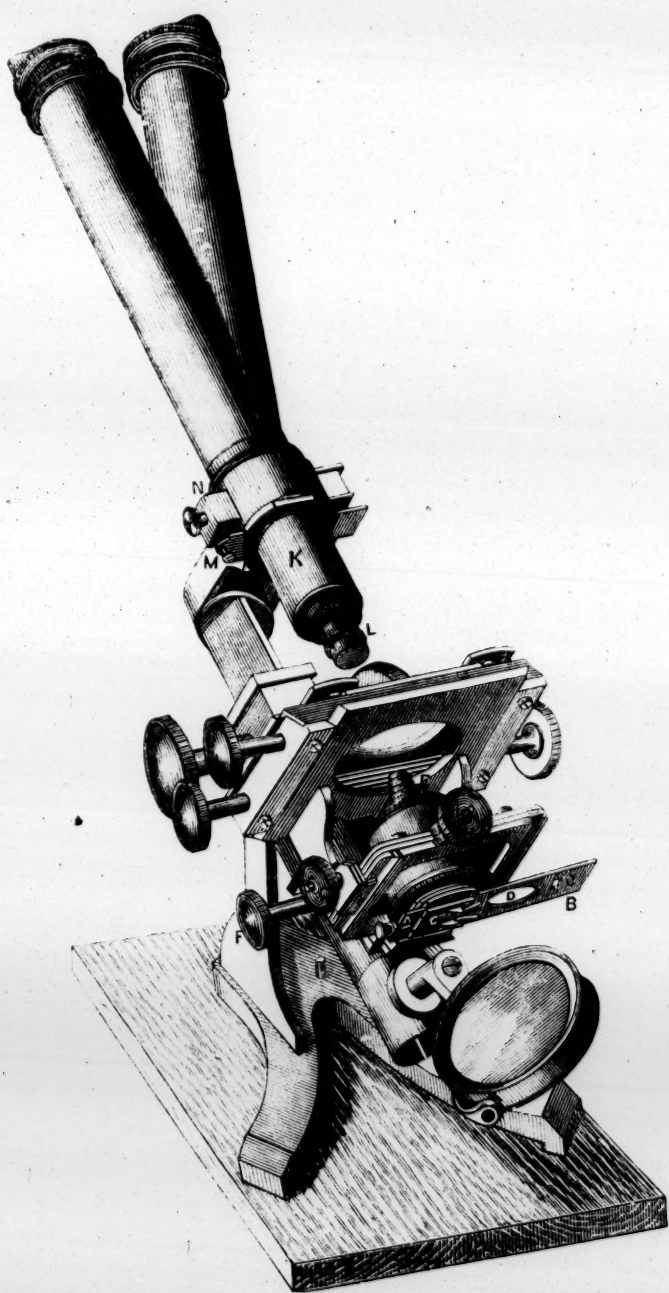
The two additions to the microscope consist of the substage with slit, &c., and the prisms in their box. The substage is of the ordinary construction, with screw adjustment for centering, and rackwork for bringing it nearer to or withdrawing it from the stage. In the accompanying engraving, A B is a plate of brass sliding in grooves attached to the lower part of the substage; it carries an adjustable slit c, a circular aperture d, 0·6 inch diameter, and an aperture o, $\frac{1}{8}$ inch square. A spring top enables either the slit or one of the apertures to be brought into the centre of the field, without moving the eye from the eye-piece. Screw adjustments enable the slit to be widened or narrowed at will, and also varied in length. At the upper part of the substage is a screw of the standard size, into which an object-glass, shown at e, of high power, is fitted. The slit c and this object-glass e are about 2 inches apart, and if light is reflected by means of the mirror along the axis of the instrument, it is evident that the object-glass e will form a small image of the slit c, about 0·3 inch in front of it. A milled head f moves the whole substage up or down

* 'Proceedings of the Royal Society,' May 27, 1869.

the axis of the microscope, whilst screws *G* and *H*, at right angles to each other, bring the image of the slit into any desired part of the field. If the brass slide *A B* is pushed in so as to bring the circular aperture *D* in the centre, the substage arrangement then becomes similar to the old form of achromatic condenser. Beneath the slit *C* is an arrangement for holding an object, in case its surface is too irregular, or substance too dense, to enable its spectrum to be properly viewed in the ordinary way.

Suppose an object is on the upper stage of the microscope, and viewed by light transmitted from the mirror through the large aperture *D* and the condenser *E*; by pushing in the lower brass slide *A B* so as to bring the slit *C* in the field, and then focusing by the milled head *F*, it is evident that a luminous image of the slit *C* can be projected on to the object; and by proper adjustment of the focus, the object and the slit can be seen together equally sharp. Also, since the whole of the light which illuminated the object has been cut off, except that portion which passes through the slit, all that is now visible in the instrument is a narrow luminous line, in which is to be seen just so much of the object as falls within the space this line covers. By altering the slit adjustments the length or width of the luminous line can be varied, whilst by means of the rackwork attached to the upper stage any part of the object may be superposed on the luminous line. The stage is supplied with a concentric movement, which permits the object to be rotated whilst in the field of view, and thus allow the image of the slit to fall on it in any direction. During this examination a touch with the finger will at any time bring the square aperture *O*, or the circular aperture *D*, into the field instead of the slit, so as to enable the observer to see the whole of the object; and in the same manner the slit can as easily be again brought back into the field.

The other essential part of this spectrum microscope consists of the prisms. They are of the direct vision kind, consisting of three flint and two crown, and are altogether 1·6 inch long. The box *K*, holding them, screws into the end of the microscope body at the place usually occupied by the object-glass, and the object-glass *L* is attached by a screw in front of the prism-box. The prism-box is sufficiently wide to enable the prisms being pushed to the side when not wanted, so as to enable the light, after passing through the object-glass, to pass freely up the body of the instrument. A pin *M* enables the prisms to be thrown either in or out of action by a movement of the finger. As the prisms are close above the object-glass, the sliding-box *N*, carrying the Wenham binocular prism and the Nicol's prism, may be employed as usual, and the spectrum of any substance may thus be examined by both eyes simultaneously, either by ordinary light or when it is under the influence of polarized light. The insertion of the prism-box between the object-glass and



THE BINOCULAR SPECTRUM MICROSCOPE,

To illustrate Mr. Crookes's article on the Spectral Phenomena of Opals.

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the body of the microscope does not interfere with the working of the instrument in the ordinary manner. The length of the tube is increased 1 or 2 inches, and a little additional rackwork may in some instruments be necessary when using object-glasses of low power. The stereoscopic effect, when the Wenham prism is put into action, does not appear to be interfered with.

For ordinary work both these additions may be kept attached to the microscope, the prisms being pushed to the side of the prism-box, and the large aperture D being brought into the centre of the substage. When it is desired to examine the spectrum of any portion of an object in the field of view, all that is necessary is to push the slit into adjustment with one hand, and the prisms with the other. The spectrum of any object which is superposed on the image of the slit is then seen.

When the spectrum of any substance is in the field and a double-image prism is introduced, two spectra are seen, one above the other, oppositely polarized, the same lines being continued through the two; and the variations in the absorption-lines such as are shown by didymium, jargonium, &c., are at once seen.

If the substance under examination is dark coloured, or the illumination is not brilliant, it is best not to divide the light by means of the Wenham prism at N, but to let the whole of it pass up the tube to one eye. If, however, the light is good, a very great advantage is gained by throwing the Wenham prism into adjustment, and using both eyes. The appearance of the spectrum, and the power of grasping faint lines, are incomparably superior when both eyes are used; whilst the stereoscopic effect it confers on some absorption and interference spectra (especially those of opals) seems to throw entirely new light on the phenomena. No one who has worked with a stereoscopic spectrum apparatus would willingly return to the old monocular spectroscope.

If the illumination in this instrument is taken from a white cloud or the sky, Fraunhofer's lines are beautifully visible, and when using direct sunlight they are seen with a perfection which leaves little to be desired. The dispersion, being four or five times greater, is sufficient to cause the spectrum to fill the whole field of the microscope, instead of, as in the ordinary instrument, forming a small portion of it; whilst owing to the very perfect achromatism of the optical part of the microscope all the lines from B to G are practically in the same focus.

As the only portion of the object examined is that part on which the image of the slit falls, and as this is very minute (varying from 0.01 to 0.001 inch, according to the actual width of the slit), it is evident that the spectrum of the smallest objects can be examined. If some blood is in the field it is easy to reduce the size of the image of the slit to dimensions covered by one

blood-disc, and then, by pushing in the prisms, to obtain its spectrum.

If the object under examination will not transmit a fair image of the slit (if it be a rough crystal of jargon, for instance), it must be fixed in the universal holder beneath the slit, and the light concentrated on to it before it reaches the slit. If the reflected spectra of opaque objects are required, they can also be obtained in the same way, the light being concentrated on them either by a parabolic reflector or by other appropriate means.

By replacing the illuminating lamp by a spirit-lamp burning with a soda-flame, and pushing in the spectrum apparatus, the yellow sodium-line is seen beautifully sharp; and by narrowing the slit sufficiently it may even be doubled. Upon introducing lithium or thallium compounds into the flame, the characteristic crimson or green line is obtained; in fact, so readily does this form of instrument adapt itself to the examination of flame-spectra, that for general work I have almost ceased to use a spectroscope of the ordinary form.

The additional facilities afforded by the use of this instrument have led the writer to the discovery of one or two facts connected with the action of different bodies on the rays of the spectrum; and it has been considered that these may be of sufficient interest to the readers of the 'Quarterly Journal of Science' to be described somewhat in detail and illustrated by a few chromolithographs.

The mineral known as *opal* has long been prized as a gem, on account of the extraordinary beauty of its colours, but the phenomena underlying these flashes of colour have not been submitted to strict scientific examination. When a good fiery opal is examined in day-, sun-, or artificial light, it appears to emit vivid flashes of crimson, green, or blue light, according to the angle at which the incident light falls, and the relative position of the opal and the observer; for the direction of the path of the emitted beam bears no uniform proportion to the angle of the incident light. Examined more closely, the flashes of light are seen to proceed from planes or surfaces of irregular dimensions inside the stone, at different depths from the surface and at all angles to each other. Occasionally a plane emitting light of one colour overlaps a plane emitting light of another colour, the two colours becoming alternately visible upon slight variations of the angle of the stone; and sometimes a plane will be observed which emits crimson light at one end, changing to orange, yellow, green, &c., until the other end of the plane shines with a blue light, the whole forming a wonderfully beautiful solar spectrum in miniature. I need scarcely say that the colours are not due to the presence of any pigment, but are interference colours caused by minute striæ, or fissures lying in different planes. By

turning the opal round and observing it from different directions, it is generally possible to get a position in which it shows no colour whatever. Viewed by transmitted light, opals appear more or less deficient in transparency, and have a slight greenish, yellow, or reddish tinge.

In order to better adapt them to the purposes of the jeweller, opals are almost always polished with rounded surfaces, back and front, but the flashes of coloured light are better seen and examined when the top and bottom of the gems are ground and polished flat and parallel.

A good opal is not injured by moderate heating in water, soaking in turpentine, or heating strongly in Canada balsam and mounting as a microscopic slide.

If an opal which emits a fine broad crimson light is held in front of the slit of a spectroscope or spectrum microscope, at the proper angle, the light is generally seen to be purely homogeneous, and all the spectrum that is visible is a brilliant luminous line or band, varying somewhat in width and more or less irregular in outline, but very sharp, and shining brightly on a perfectly black ground. If, now, the source of light is moved so as to shine into the spectrum apparatus *through* the opal, the above appearance is reversed, and we have a luminous spectrum with a jet-black band in the red, identical in position, form of outline, and sharpness, with the luminous band previously observed. If instead of moving the first source of light (the one which gave the reflected luminous line in the red) another source of light be used for obtaining the spectrum, the two appearances of a coloured line on a black ground and black line on coloured ground may be obtained simultaneously, and they will be seen to fit accurately.

Those parts of the opal which emit red light are, therefore, seen to be opaque to light of the same refrangibility which they emit; and upon examining in the same manner other opals which shine with green, yellow, or blue light, the same appearances are observed, showing that this rule holds good in these cases also. It is doubtless a general law, following of necessity the mode of production of the flashes of colour.

Having once satisfied myself that the above law held good in all the instances which came under my notice, I confined myself chiefly to the examination of the transmitted spectra, although the following descriptions will apply equally well, *mutatis mutandis*, to the reflected spectra.

The following is a brief description of some of the most curious transmission spectra shown by these opals. The chromo-lithographs forming the frontispiece, taken from drawings with the camera lucida, convey as good an idea as possible of the different appearances. The exact description will, of course, only hold good

for one portion of the opal, but the general character of each individual stone is well marked.

The simplest form of band which is met with is shown in Spectrum 1, which represents the spectrum after passing through one of my experimental opals. It is one of the best examples I have met with of a narrow, straight, and sharply cut line. It is in the green, and might easily be mistaken for an absorption-band caused by an unknown chemical element.

Spectrum 2 shows a band of a very remarkable character; it is broad and black, and cuts diagonally across the green, touching the blue at the top and the yellow at the bottom.

Spectrum 3 is somewhat similar; it shows a broad indistinct diagonal band in the blue, and another still more indistinct in the violet.

So far the bands have been simple lines, and the only peculiarity has been the diagonal character of some of them. I now wish to draw attention to a most remarkable phenomenon presented by some opals, and that is the production in their transmission spectra of irregularly shaded lines, which when examined in the binocular spectrum instrument appear distinctly spiral, and, on moving the opal, roll over on their axis from one part of the spectrum to another. Spectrum 4 is an example of this kind; it shows an irregular line in the orange. Viewed binocularly this exhibits a spiral structure in a marked manner, the different depths and distances standing well out: upon turning the milled edge of the stage adjustment, so as to carry the opal slowly from left to right, the spiral line is seen to revolve and roll over, altering its shape and position in the spectrum. It is not easy to retain the conviction that one is looking merely at a band of deficient light in the spectrum, and not at a solid body possessing dimensions and in actual motion.

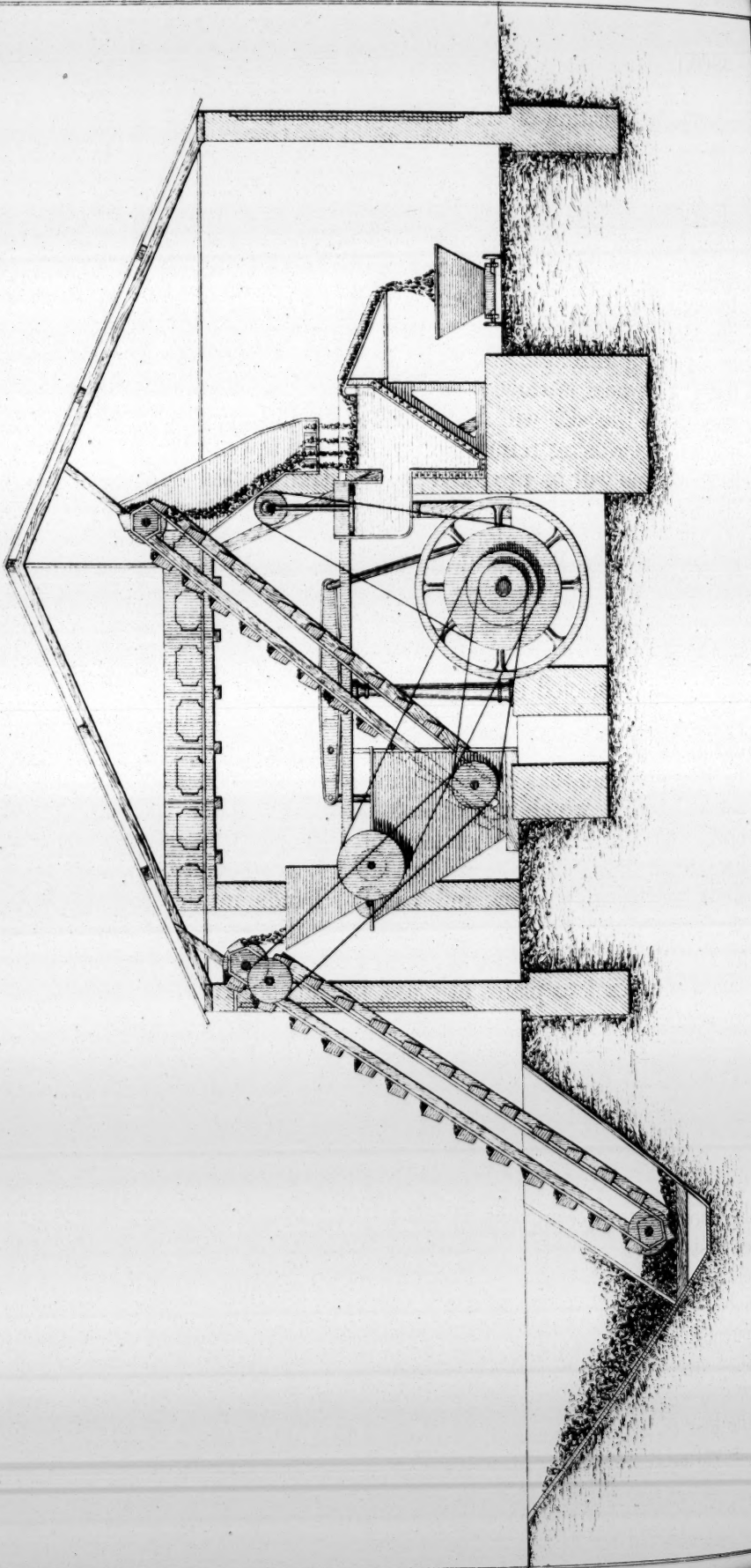
Spectrum 5 shows the most striking example of a spiral rotating line which I have yet met with. On moving the opal sideways the line is seen to start from the red and roll over, like an irregularly shaped and somewhat hazy corkscrew, into the middle of the yellow. The drawing shows the appearance of this band in two positions.

It is scarcely necessary to say that the colour of the moving luminous line varies with the part of the spectrum to which it belongs. The appearance of a luminous line, slowly moving across the black field of the instrument, and assuming in turn all the colours of the spectrum, is very beautiful.

All these black bands can be reversed, and changed into luminous bands, by illuminating the opals with reflected light. They are, however, more difficult to see, for the coloured light is only emitted at a particular angle, whilst the special opacity to the ray of the same refrangibility as the emitted ray holds good for different angles.

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LONGITUDINAL SECTION OF COAL WASHING MACHINE, WITH ENGINE &c.



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The explanation of the phenomena is probably as follows:—In the case of the moving line, the light-emitting plane in the opal is somewhat broad, and has the property of giving out at one end, along its whole height and for a width equal to the breadth of the band, say, red light; this merges gradually into a space emitting orange, and so on throughout the entire length of the spectrum, or through that portion of it which is traversed by the moving line in the instrument; the successive pencils (or rather ribbons) of emitted light passing through all degrees of refrangibility. It is evident that if this opal is slowly passed across the slit of the spectrum microscope, the slit will be successively illuminated with light of gradually increasing refrangibility, and the appearance of a moving luminous line will be produced; and if transmitted light is used for illumination the reversal of the phenomena will cause the production of a black line moving along a coloured field. A diagonal line will be produced if an opal of this character is examined in a sloping position.

The phenomenon of a spiral line in relief, rolling along as the opal is moved, is doubtless caused by modifying planes at different depths and connected by cross-planes; I can form a mental picture of a structure which would produce this effect, but scarcely clear enough to enable me to describe it in words.

It is probable that similar phenomena may be seen in many, if not all, bodies which reflect coloured light after the manner of opals. A magnificent specimen of lumacelli, or fiery limestone, from Italy, kindly presented to me by my friend David Forbes, shows two sharp, narrow, and parallel bands in the red. I have also observed similar appearances in mother-of-pearl. The effects can be imitated to a certain extent by examining "Newton's rings," formed between two plates of glass, in the spectrum microscope.

II. COAL WASHING.

By F. C. DANVERS, A.I.C.E., M.S.E.

In most mining operations it has been the practice, from the earliest times of which we have record, to wash the minerals obtained from beneath the surface of the earth in water, before subjecting them to further purification by means of fire, for the purpose of separating a portion of the earthy matters, with which they are invariably mixed, from the ore. In former years this was accomplished in a very rude manner, which doubtless involved the loss of a not inconsiderable amount of pure ore. Dr. Percy, in his valuable work on Metallurgy, gives an historical notice of the

mode of making iron in South Wales about the year 1750, in which it is stated as follows:—"On the wash, or enclosed ground on the sides of the hills, where we find oar, we dig a trench about 4 or 5 foot wide, till we come down to the lowest vein, about 14 foot deep, and in that depth is usually four veins or layers of oar. Then we make small ponds to hold rain water, or any that comes out of springs, above the trench that is cut; and as fast as the ponds fill, we let them down by a flood-gate into the trench, which carries away all the loose earth, and leaves the myne behind, and the lowest vein bare. They then undermine the banks of the trench on both sides, and when great quantities of the banks are fallen down, they let down the water out of the ponds again, which washes away all the earth from the myne." Such then was the rude method of washing iron ore 120 years ago; but although so primitive in method, the principle, it will be recognized, was the same as that which prevails in ore-washing machines of the most approved type at the present day, the separation of the ore from the earthy matters being due to gravitation. Thus whilst the lighter particles were carried away by the water, the heavier and mineral portions were left behind.

Although coal washing has now been practised all over the Continent for about half-a-century, until comparatively quite recently the practice of washing the products of coal mines was unknown in this country, and for the following reasons. Coal, unlike almost every other mineral product, is found running in broad seams, varying from a few inches to many feet in thickness; and so great is the quantity in which it exists that the richer seams only are considered worth working at all, and from these blocks are obtained, possessing a very high degree of purity. Not many years back, it was the custom to leave all the small coal down at the bottom of the pit, or, if it was brought to the surface, it was either burned at the pit's mouth as so much worthless refuse, or run to spoil. Indeed so wasteful has been the manner in which coal-mining operations have been carried on, that large quantities of valuable fuel have been lost, or habitually left at the bottom of the pit as not being worth raising to the surface. This subject was closely investigated in 1860, by Mr. Alexander Bassett, of Cardiff,* the result of whose inquiries showed that from thirty to forty per cent. of the products of mines is not unfrequently lost, owing to the imperfect method of coal "getting" usually adopted; but that where, either from the character of the seam of coal, or from the mode adopted in working, a less percentage of fuel is lost, "still, under the most improved system, the quantity of small coal left in the mines, and conse-

* "On the Large Proportion of Coal lost in Working." Paper read before the South Wales Institute of Engineers, in February, 1861, by Mr. Alexander Bassett, M.I.C.E.

quently for ever lost, bears a very large proportion to that raised, and which could be brought to bank, if a market were obtained for it."

Since attention was so forcibly called to the probable duration of our coal supplies by Sir William Armstrong at the Meeting of the British Association at Newcastle in the year 1863, measures have been devised with the view of utilizing that which was formerly counted as waste, and the small coal is no longer permitted to lie unheeded at the bottom of the pit. In collecting the slack, however, in addition to any impurities which it contains as coal, such as shale, iron pyrites, &c., there will invariably be found mixed with it portions of rocky or earthy matters which have fallen from the roof of the heading during working, or which may be taken off from the floors of the passages whilst collecting the small coal for the purpose of sending it to the surface. Under these circumstances, it is not to be wondered that the slack coal thus obtained contains a much greater amount of earthy impurities than does the coal from the same pit, hewn and sent to bank in larger or smaller blocks. As has been already stated, this slack coal from the pits was formerly considered to be worthless, or, at any rate, not of sufficient value to enable it to bear the cost of transport in order to bring it to market; recent experience has, however, shown, not only that such is not the case, but that what was formerly looked upon as so much refuse, may be readily separated from the impurities with which it is in a great measure mixed, and thus purified it obtains a ready sale either for cokeing purposes or for the manufacture of artificial fuel.

The general large yield of English coal beds may, no doubt, be assigned as the chief cause which formerly led to the adoption of an extravagant mode of working them, and this was further stimulated by an absence of machinery for the purpose, and a want of that knowledge on the subject which has in comparatively recent times been acquired and put into practice.

The inferior quality of a portion of the coal measures of France and Belgium, and, in the former country especially, the comparatively small area over which they extend, led to the adoption of greater economy in working; and it is not therefore surprising to find that England is indebted to France for the introduction of the practice of coal washing, whereby the small and formerly unproductive yields of coal are now raised into an important branch of trade. Only a small portion of it is however brought into use in the manufacture of artificial fuel. That article is at present scarcely used in England, and the small quantity that is manufactured here is made almost exclusively for export. From the latest returns published, namely those for 1867, it appears that the amount of artificial fuel exported during that year from the United Kingdom was only 150,051 tons, which may be taken to

represent nearly the whole manufacture of it in this country. By recent improvements it is now possible to burn small coal in boiler furnaces, but by far the greatest portion of washed coal is converted into coke, for which purpose it is specially adapted, and at most large collieries in the country there may now be seen a coal-washing machine and ranges of cokeing ovens as part of the indispensable plant of the colliery proprietor.

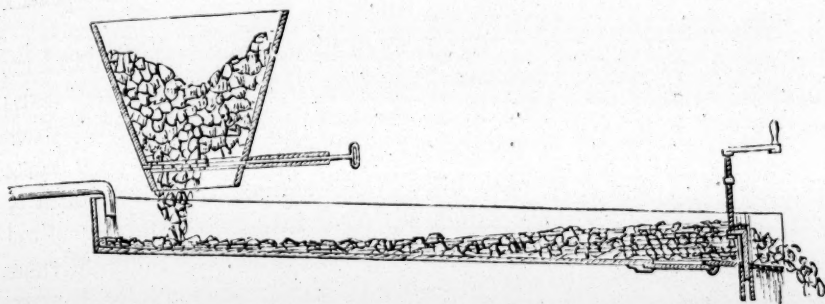
About sixteen years ago a Mr. Morrison first introduced into this country a coal-washing machine from France, and having obtained certain concessions from some of the north-country coal-owners, he proceeded to set the apparatus to work, and soon became celebrated for the superior quality of the coke manufactured by him. It was, however, some years before the principle of coal washing became at all general, and for some time Mr. Morrison was the only person to carry it into practice. Gradually, however, the process was taken up, first by one, and then by another, until a washing machine has now become almost as necessary an adjunct to a colliery as a pumping engine.

Very little alteration appears to have been hitherto made in the general principles of the first coal-washing machine introduced into this country, but alterations in detail have materially conduced to its greater efficiency and economy in working. As in the case of most other useful inventions, all sorts of modifications have been from time to time suggested, but few appear to have sufficiently recommended themselves on their own merits as to obtain any success. In all cases, excepting where only slack is washed, the coal has first to be broken up small, in order to prepare it for the washing machine. The means generally employed for separating the impurities from coal is gravitation, the mineral to be washed being thrown into water, when the earthy matters sink to the bottom, whilst the coal, being the lighter, forms an upper layer which is easily removed.

Numberless contrivances have been proposed for more readily effecting this disposition of strata in the washing machine, but, with the exception of those which we shall presently notice, few have come into general adoption; and whilst many other plans have been projected for removing the impurities from coals, those in which water is employed, either in a running stream or in agitation, as will be presently described, alone appear to have been brought into practical use. In order to give a better understanding of how the last-named machines effect this separation, we shall first describe them more in detail, and then proceed to give some further particulars regarding the methods requisite to prevent any unnecessary waste of fuel; since, if care be not taken, much coal is liable to be carried away with the waste water, after it has passed through the machines.

The simplest, but by no means the most efficient, form of coal-washing machine is that consisting of a simple trough, or passage, having a smooth channel, and set on a slight incline in the direction of its length, as shown in the accompanying woodcut. At the

FIG. 1.



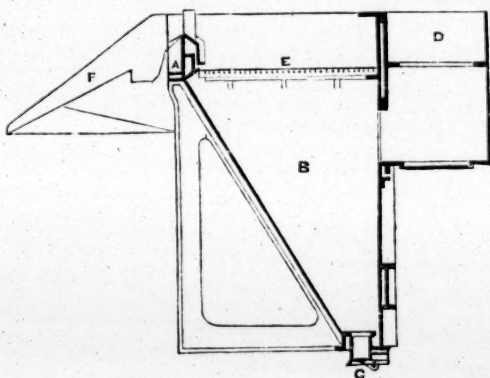
lower end, the trough is fitted with a vertical sliding sluice valve, working up through the bottom, and in grooves in the sides, which may be elevated or depressed at pleasure by means of a screw; and just above this sluice is placed a valve, opening in the bottom or side of the trough. The mode of working is as follows. The coal to be washed is either first crushed by passing it between rollers, or, as is sometimes the case, the trough is placed under the screen, over which the coals are tipped in passing from the trucks, as they come from the pit, into the railway waggons. The finer particles of coal then, passing through the meshes of the screen, fall into the trough at its upper or more elevated extremity, into which also a continuous flow of water is admitted. The coal is thus carried down the channel by the water, and it has to be kept constantly agitated during its passage, either by means of a long pronged fork worked by hand, or by a mechanical apparatus designed for the purpose. This agitation is necessary to ensure the more perfect separation of the coal from its impurities. As it flows down, the coal, being lighter than the shale or pyrites, rises to the top, whilst the heavier particles settle down and remain in the bottom of the trough. The coal then is permitted to pass over the sluice at the lower end of the shoot; but as the impurities accumulate, the sluice is gradually raised to prevent their passing away with the coal, and this is done until the sluice has been raised to a height nearly level with the top of the sides of the trough. The supply of coal is then temporarily turned off, and the valve opened in the bottom of the trough, through which the impurities are allowed to pass. The sluice is then lowered, and the same operation is repeated. In some machines of this type the trough is made very long, and a sluice is placed in the middle of its length as well as at the extremity.

Attempts have also been made to dispense with the necessity for stirring the coal whilst being washed, by placing a series of projections across the bottom of the trough, which, acting as submerged weirs, were intended to give the water an undulatory motion; this, however, is not sufficient for the purpose, and experience has shown that a more sudden and violent action of the water is necessary in order to effectually separate the coal from its impurities. The objections to this form of coal-washing machine are that, whilst it requires a larger supply of water for the purpose, the coal is not so thoroughly washed as in other machines; and that whilst the result is still only comparatively purified, a large amount of coal is probably wasted, by passing away with the other matters down the outlet valve before referred to.

The most generally adopted plan of coal-washing machine at present in use is that shown in the Plate accompanying this article. It is a modification of a French machine, the invention of one M. Berard, and somewhat of the form of that first introduced into this country by Mr. Morrison. The illustration represents not only the washing machine itself, but the steam engine and other auxiliaries employed in connection with it. In this machine the coal, after passing between crushing rollers, is conveyed by means of a "Jacob's ladder" into a hopper, or shoot, down which it falls into small rectangular troughs, at the head of each of which a current of water enters which carries the coal away, and deposits it on a wire, or perforated copper sieve. Beneath this sieve is a hopper-formed chamber filled with water in communication with the bottom of a cylinder in which a piston works at the rate of about 100 strokes per minute. The motion of this piston agitates the water in the "bash," causing it alternately to rise and fall on the sieve. The coal on the sieve is thus kept in a constant state of motion, being lifted up by the water as the piston descends, and falling again with its upward stroke. By this constant elevation and resettling, the heavier particles, which constitute the impurities in the coal, fall to the bottom and form the lowest stratum on the sieve; whilst the pure coal, after the space above the sieve is once full, is carried over the lip of the machine with the escaping water, and falls down a shoot into a truck placed there for the purpose of receiving it. As soon as any shale, or other impurity, is seen to pass over with the coal, or when the space over the sieve becomes filled with foreign matter (which may be readily ascertained by the attendant taking a small quantity out to examine it), the valve at A, Fig. 2, is raised by means of a screw, or weighted lever, and the accumulated impurities are allowed to pass into the lower part B, from which they are subsequently removed by means of the valve C at the bottom of the machine. The piston works in the chamber D. It should have a stroke of not more than from 2 to 2½ inches, and

is usually driven at the rate of about one hundred strokes per minute. *E* is the sieve on which the coal rests, and after being washed it passes away over the shoot *F*. A machine of this character, with pistons of 3 feet diameter, and "bashes" about 3 feet by 4 feet, will require a supply of about 32 gallons of water per minute for each "bash," and is capable of washing about 50 tons of coal per day per "bash." A four "bash" machine, capable of purifying nearly 200 tons of coal a-day, requires about a 12-horse-power steam engine to work it and the auxiliary machinery.

FIG. 2.



Having thus briefly explained the details of the washing machine itself, we pass on to notice the entire process through which the coal has to pass. The coal is brought direct from the pits in trucks, and emptied into the hopper sunk below the level of the ground, as shown in the left-hand corner of the engraving. Thence, if the situation does not admit of putting a pair of crushing rollers into the first reception pit, it is carried by a Jacob's ladder, and thrown into a hopper, through which it passes to the crushing mill, to be broken up into a suitable size for washing, by which process also the attachment between the coal and its impurities is severed or loosened. After passing through the rollers it is lifted up into another hopper, whence it falls into a number of short shoots corresponding with the number of "bashes" in the machine, and, a little above the point in the shoots where the coal enters, water is admitted through a service pipe, by means of which the coal is carried down on to the sieve, and the washing proceeds in the manner already explained.

According to one modification of this machine, which is in extensive use at Saarbruck, in Germany, a number of "bashes," instead of working separately, act together; the washed coal from one "bash" falling over a small weir into the next, and so on until it has passed through the entire series. Although, no doubt, by this mode a much greater degree of purity is obtained in the washed coal, the plan of using the "bashes" separately, as practised in this country, is found to give results sufficiently satisfactory for all practical purposes; to continue the process further would, therefore, only be to incur additional expenditure without corresponding results.

Another modification of the above process ought not to be passed by without notice, for, whilst it embodies most of the leading principles of Bérard's machine, it has been so adapted as to produce the greatest possible effect with the least practicable amount of water and the smallest expenditure of power. The modifications in this machine—which has been designed by a Mr. Edwards—will be sufficiently well understood without an illustration, from the following description :—The coal and water are admitted together through a hopper on to the sieve, and instead of a piston, for keeping the water in the machine in a state of agitation, a float is placed so as to rest upon the surface of the water at a level below that of its height over the sieve. This float is attached to the top of the cistern, and the joint made water-tight by a leather flange, which admits of a certain amount of vertical movement by the float. The motion is given to the float by means of a three-throw cam; as the cam strikes the float, it is deflected, causing the water on the sieve to rise, in the same way as with the downward stroke of the piston in the machines already described. Indeed the float is in this case a piston working on the water only without any cylinder to work in.

Directly the cam releases the float, the head of water forces it back, ready to receive the next stroke. Instead of making the water act as the means of conveying the washed coal from the machine, as in Bérard's and most other modifications of that machine, a set of scrapers gradually carry it forward, and finally push it over the delivery end of the machine, and thus less water is required. The speed at which the motion shaft is driven need be but one-third that of Bérard's, in order to obtain the same amount of work. One of Edwards's machines, capable of washing about 50 tons of coal per day, requires so little power to move it, that, were it not for the auxiliary crushing rollers, &c., which are generally indispensable with a coal-washing machine, it might be worked by manual power.

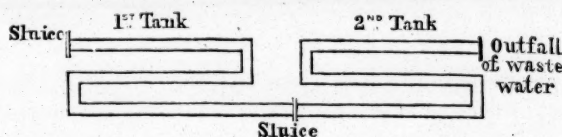
Most coal-washing machines are arranged so that the washed coal falls directly into a truck ready for removal to the cokeing ovens, to the artificial fuel manufactory, or any other destination. The coal thus caught forms, however, only a portion of what passes through the washing machine. It constitutes indeed the greater portion of it, and consists of all the larger pieces of coal, whilst many of the smaller particles and almost all the coal dust are carried away by the water as it flows off. In order to save this fine coal, which, it is found, contains the smallest amount of impurities, and is therefore best adapted for the manufacture of coke, it is necessary to form settling tanks through which all the water from the machine is made to pass. So much coal, however, escapes if due care be not taken, that it has in practice been found desirable

to have at least three such tanks, each of which should be in duplicate, so that one set of tanks may be kept at work whilst the coal which has collected in the other set is being removed. Sometimes a fine mesh wire gauze, or finely perforated plate, is placed at the outlet of the first settling tank for the purpose of keeping back all pieces of coal above a certain size, but it is very doubtful whether such a precaution is necessary, as the larger pieces are sure to be deposited in the first tank, whilst the finest of all will be found at the bottom of the last settling tank. Even after all these precautions have been taken to save as much of the coal as possible, the author has witnessed instances where samples, collected promiscuously from the residue which escapes with the water after it has passed through the last settling tank, have been found to contain seventy-five per cent. of combustible matter, but it is certain that a small portion only of this consisted of pure carbon. Under a judicious arrangement of settling tanks it will be almost invariably found that the deposited coal becomes more pure in each successive tank up to the third, and that what is subsequently found to be held in suspension by the water contains too large a proportion of impurities to render it worth the trouble and expense of collecting.

Too much attention can hardly be given to the construction of settling tanks, whatever form of washing machine is employed, since, in the first place, the fine coal passing away with the water is the purest and best adapted for the manufacture of coke, and secondly, unless this be carefully conserved the loss consequent upon the operation of washing may be such as to make it very questionable whether the cost is not out of all proportion to the benefits otherwise obtained. Even in a well-arranged coal-washing establishment the loss in weight by washing will often be found equal to from twelve to fifteen per cent., consisting of the impurities extracted, as well as a certain amount of small coal, which, as has been before explained, will always escape with the waste water. So far as the author's experience goes, there appears generally to exist at collieries a strong objection to devote a sufficient extent of ground to the proper construction of settling tanks. In setting them out care should be taken that the tanks are made only of such a width that they can be readily cleared out without the use of wheel-barrows; for this purpose they should not be more than 6 feet wide, and about 3 feet deep at the outside, and on either side of each tank trams should be laid, at a level somewhat below the surface, so that men may shovel the deposited coal directly into waggons. The tanks also should not consist of one long narrow trench each, as is most generally the case. For a large coal-washing establishment such an arrangement would be very inconvenient, and besides, it would not be found to work so well nor to deposit so much coal as if each tank were made to consist of three

or more rows of narrow trenches, communicating with each other at alternate ends, somewhat in the following manner.

FIG. 3.



Here it will be seen advantage is taken of the known tendency of any obstruction in the flow of water to cause it to deposit whatever matter it may hold in suspension. The total area of tanks required for any coal-washing works must depend upon the extent to which it is proposed to carry on such work, as well as in some measure upon the available amount of water for the purpose; it would, therefore, not be possible to lay down any general rules upon that subject, which must be determined after a consideration of the special circumstances of each case.

The cost of washing coal varies very much at different collieries, but it may be assumed that, on an average, it should not exceed threepence or fourpence per ton. At some places the washing is done by contract, one man receiving a certain sum for each ton of coal washed, and providing all the labour necessary, and paying all expenses connected with the operation. At other establishments, the engine employed to drive the washing machine may, perhaps, also be connected with other machinery, although it is better, in all cases, that it should have an independent engine for its own use. Under such circumstances, the cost of working the engine would be borne by the proprietors, and the person contracting would, of course, not be entitled to receive so high a price as if he were responsible also for the whole duty of the engine.

The practice of coal washing is, as we have already explained, a comparatively modern introduction in the economy of colliery management; but so rapid has been its extension within the last few years, that it is now coming into very general use. The advantages of thus purifying the slack of our coal mines are numerous, and calculated to benefit alike the producer and the consumer; for whilst it practically extends the available yield of our coal beds, it should have the effect of checking any inordinate increase of prices, if it do not actually tend to reduce the cost to the public at which certain classes of coal are now obtainable.

III. ON THE TEACHING OF NATURAL SCIENCE AT THE UNIVERSITIES.

THE indifference shown to the cultivation of the natural sciences in our leading public schools led to the appearance in the last number of this Journal of an article by our esteemed contributor, Dr. Lankester, which has caused no little discussion in circles where an interest is felt in such studies.

Whether or not the great chartered schools of Rugby, Harrow, Winchester, &c., are likely to be moved by the appeal of one who has spent a long life in promoting the study of natural science, and will appoint suitable professors and lecturers, we are unable to say;* but one result of the appearance of Dr. Lankester's article has been to show us that our Universities are by no means open to the charge of neglecting science, and are fully alive to the value of scientific studies.

We have received what we are bound to say are just protests against the neglect of science being laid to the score of the Universities, and consequently we hasten to rectify any erroneous impression which may have gone abroad as to the amount of time and money really expended at our Universities for the purposes of science tuition. And it affords us all the more pleasure to do this, inasmuch as we believe the public indifference to scientific knowledge has caused the efforts which have for some time past been made by the Universities to be overlooked, or to remain quite unknown, except to those who have been obliged by professional requirements to make science a portion of their education.

The fairest way, then, will be to let each University speak for itself; and as the first and loudest remonstrance reached us from Oxford, we shall print verbatim the programme of lectures, &c., with which it was accompanied.

The signature will remind our readers that the University possesses one of the most excellent museums in the three kingdoms, and that Drs. Rolleston and Phillips, Mr. Westwood, and others have long striven to make it as perfect as possible for educational purposes.

* Since this article was written we have been informed that a good deal is being done at Rugby and Harrow now. Good men are sent up for the Oxford scholarships from Rugby; and at Eton there has just been established a mastership in Natural Science, a gentleman having been engaged who was formerly Sir B. Brodie's demonstrator at Oxford.

SYNOPSIS OF LECTURES IN THE UNIVERSITY MUSEUM, OXFORD,
LENT TERM, 1869.

Professorship.	Professor.	Subject.	Days and Hours.	1st Lecture.
GEOMETRY	H. J. S. Smith, M.A. . .	An-harmonic Properties.	Monday, Friday, 1 P.M.	Friday, Jan. 22.
ASTRONOMY	W. F. Donkin, M.A.			
NATURAL PHILOSOPHY } ..	B. Price, M.A. . . .	Dynamics of Material Systems.	Tuesday, Thursday, Saturday, 1 P.M.	Thursday, Jan. 21.
EXPERIMENTAL PHILOSOPHY } ..	R. B. Clifton, M.A. . .	Acoustics (continued).	Monday, Thursday, 12.	Monday, Feb. 1.
MINERALOGY	M. N. S. Maskelyne, M.A.			
CHEMISTRY	Sir B. C. Brodie, Bart, M.A.	A Syllabus may be obtained at the Laboratory.	Tuesday, Saturday, 11 A.M. Catechetical Lecture, Thursday, 11 A.M.	Thursday, Jan. 28.
ANATOMY AND PHYSIOLOGY } ..	G. Rolleston, D.M. . .	Circulation and Respiration.	Tuesday, Friday, Saturday, 1 P.M.	Friday, Jan. 22.
GEOLOGY	John Phillips, M.A.			
MEDICINE	Henry W. Acland, D.M.	General and Clinical Medicine.	Tuesday, Saturday, 11 A.M.	Tuesday, Feb. 2.
BOTANY AND RURAL ECONOMY } ..	Marmaduke Lawson, M.A.			
ZOOLOGY	J. O. Westwood, M.A.			

The University Laboratory is open daily from 10 A.M. to 4 P.M.

Classes are formed for practical instruction in Anatomy and Physiology. Gentlemen who join these Classes come to the Lecture on Saturday, and also attend on two other days in the week for study and demonstration.

Dr. Beale will give Demonstrations in Histology on Tuesday, January 26, at 8 P.M., and on following Tuesdays, at the same hour.

Mr. Chapman will continue his Course of Lectures on Physiology.

Mr. Wyndham will continue his Course of Lectures on Chemistry in Merton College.

J. PHILLIPS, *Keeper of the Museum.*

Passing on to the sister University, some of our readers have unfortunately been led by Dr. Lankester's article to think that the two lectureships named by him, as having been recently established, are the only chairs in natural science in the University; but this impression is not correct. At Cambridge there are professorships of physic, mathematics, chemistry, astronomy, and experimental philosophy, anatomy, botany, geology, a second of astronomy, geometry, medicine, natural and experimental philosophy, mineralogy, and archæology; and examinations in all those subjects, as well as in mechanical and applied science.

Of London University it is hardly necessary to speak. Its numerous scholarships and its degrees of Bachelor and Doctor of Science have done as much, perhaps more than any institution in the world, for the promotion of scientific education. Nor must the large public schools and colleges in London and the provinces which are connected with it be overlooked. Of these it is only necessary to mention University and King's Colleges, London; Owen's College, at Manchester; Queen's Colleges, at Birmingham and Liverpool, to remind our readers that great efforts are made to provide scientific instruction for those who seek it.

The Scotch Universities have not been idle. One of our correspondents, who complains that justice has not been done to Edin-

burgh University, sends us the following details, to which we gladly give publicity:—

"Systematic instruction in botany, chemistry, natural history (in which are included zoology, geology, mineralogy, physical geography, and meteorology), natural philosophy, including optics, heat, electricity, magnetism, hydrostatics, and mechanics, has for a very long period been imparted in the University of Edinburgh. The chair of botany was founded in 1676, that of chemistry in 1713, and that of natural history in 1767; the chair of natural history is also old-established. The instruction imparted from these chairs is not merely in the form of lectures; but laboratories, museums, and a botanic garden are provided for the practical instruction of the students. The students attending botany, chemistry, and natural history are, to a considerable extent, medical, but a very fair proportion of general students participate in the instruction. Attendance in the class of natural philosophy is imperative on all candidates for the degree in Arts conferred by the University, but many students who have no intention of proceeding to the Arts degree also attend. Candidates for honours in the faculty of Arts can, if they choose, present themselves for examination in geology, zoology, chemistry, and botany.

"The University also confers the degrees of Bachelor and Doctor of Science. Candidates are examined in botany, chemistry, zoology, geology, natural philosophy, and mathematics. Through the liberality of Sir D. Baxter, scholarships in the natural and physical sciences have been founded."

Speaking of other Scottish institutions, our correspondent goes on to say that in Glasgow and Aberdeen there are corresponding chairs in the biological and physical sciences; and he also forwards us a programme of the course of science-teaching in the High School at Edinburgh, which embraces chemistry, natural philosophy, zoology, and botany.

Turning now to Ireland, from whence, too, an admonition has reached us, we believe we can safely say that whilst the Universities (Dublin and Queen's) do all they can to set a good example, nothing is done by the public schools.

At Dublin, moderatorships in experimental science were first given in 1851, the course consisting of physics, chemistry, and mineralogy. Subsequently geology was introduced, and in 1858 zoology and botany were added; and the name of the moderatorships changed to "Experimental and Natural Science."

There are professorships of mathematics, natural philosophy, chemistry, zoology, botany, civil engineering, geology, applied science, and mineralogy; to these, museums of natural philosophy, zoology, and archaeology, anatomy, engineering models, and botany are made subservient.

At the Queen's University, science is largely cultivated, and there are professorships of natural philosophy, chemistry, natural history, geology and mineralogy, anatomy and physiology, and engineering; scholarships are awarded in science, and a special diploma for engineering.

Thus it will be seen that in all our large Universities ample provision is made for science-teaching, and it is greatly to be feared that the reason why this branch of human intelligence has not been hitherto more largely cultivated there, is not so much on account of the indisposition of the College authorities to afford instruction, as to the unwillingness of the students to receive it.

The late respected Dr. Daubeny wrote to the writer of this article some time before his death, expressing his regret that more encouragement is not given to the study of science by the middle classes. A demy-ship in natural science at Magdalen College, he said, was literally going a-begging, and the writer was asked whether he could recommend a candidate. One reason for this indifference—probably the chief one—was soon made apparent when the attempt was made to comply with the Doctor's wishes. "What am I to do for a living, after I have completed my studies?" asked one young man. And this question contained the solution of the mystery—science does not pay. The great prizes are to be found at the Bar, or in the career of a statesman, and unfortunately scientific knowledge is not yet appreciated in those professions.

But why the Universities of Oxford and Cambridge should withhold honour where there is no profit; should offer facilities for instruction and yet deny the student the reward of merit, is a mystery. The sooner they encourage the pursuit of science by conferring degrees for its proficiency, and thus making it at least an honourable profession, the better it will be both for the teacher and the taught. We trust the day is not far distant when the example of the Universities of London and Edinburgh will, in this respect, be followed by the older Universities, which should rather lead than follow in every intellectual movement of the day.

IV. THE MINERALOGICAL RESOURCES OF IRELAND.

As compared with either England or Scotland, the mineral resources of Ireland are limited in extent, and not very rich in kind. Of several species of rocks and formations, which are of economic value, there is indeed an abundance. Ireland can produce the noblest specimens of granite, serpentine and marble, and prodigious quantities of limestone, chalk, and other massive rocks; but when we

come to consider the extent and nature of her resources in coal or iron, we cannot but feel that she labours under disadvantages which go far to explain the causes of the comparative impoverishment and the almost purely agricultural habits of her population.

Without large supplies of coal and iron, especially the former, it is needless to say that no country can take a foremost rank in those arts and manufactures which are the sinews, not only of war, but of peace. And notwithstanding the deficiency in these commodities, from which Ireland suffers, it is highly to the credit of the inhabitants of Ulster that in one branch of manufacture—the linen trade—this province has no superior, scarcely a rival. This branch of manufacture, introduced by the Protestant refugees from France, is carried on by the aid of imported coal and native-grown flax, and has been the means of making the town of Belfast the second in importance only to Dublin, and amongst the most thriving, spirited, and industrious centres of industry in the British empire.

But notwithstanding several successful attempts in Belfast, Dublin, and elsewhere, to compete with the sister-country in engineering, ship-building, and iron manufacture, Ireland is, and must ever be, an agricultural and pastoral country. For this she is peculiarly adapted by the genial character of the climate and the richness of the soil; for any other she is disqualified. We look in vain for those vast deposits of coal, or those stores of iron ore, with which England and Scotland have been so richly endowed, and from which they derive such solid advantages. Nature has, we think, dealt hardly by the sister-isle; for we have very good evidence for believing, on geological grounds, that the coal-fields of Ireland must have been, at some distant period, proportionably greater, as regards the area of the country, than those of Britain. This assertion may startle some persons who are not versed in the process of inductive reasoning on geological principles; and, for their sake, we shall shortly state the grounds upon which we base this conclusion.

If we examine the coal-fields of England, we shall find that, with few exceptions, their lowest strata repose upon a basis of Carboniferous limestone. Whether we examine the coal-bearing tracts of South Wales, Gloucestershire, and Somersetshire on the south, or of North Wales, Lancashire, Cumberland, &c., on the north, we find layers of this limestone supporting strata of shale, sandstone, and grit, which become more carboniferous as we ascend in the series; and ultimately pass up into the series of strata which, on account of their most important feature, are denominated "Coal-measures." Now, throughout this series of strata we observe a gradual change from the calcareous beds at the base to the coal-bearing shales and sandstones of the upper part; the limestones near their junction with the Millstone grit and Yoredale beds

becoming gradually more earthy, and being split into separate layers by the intercalation of shales and sandstones. Throughout the whole series, amounting vertically to several thousands of feet of strata, there is no abrupt change, or break, in the succession of the beds of any importance; a fact which should be borne in mind, because on it depends much of the strength of our reasoning from analogy when we come to the case of Ireland.

Now, reverting to this country, what do we find? We find the very same succession of strata, from the base upwards, through a certain distance in the vertical scale, but no farther. We may observe the Carboniferous limestone—the basement layer of the coal-bearing superstructure in Britain—spread over an enormous tract of country, and forming nearly the whole of the central plain of Ireland; and resting on this, at intervals, we have small tracts of strata, with a few thin seams of coal, representing the Millstone grit and Yoredale series of England and Wales; but here the succession ends. We look in vain for the deposits of coal-bearing strata—or true Coal-measures—which in Britain are the repositories of the most important beds of mineral fuel.

To account for this want—this truncation, in fact, of the most economically important portion of the great Carboniferous formation in Ireland—the geologist has a theory which is intelligible and consistent with experience as obtained in some parts of Britain itself. Our readers are probably familiar with the tracts of hilly ground in parts of Yorkshire and Derbyshire, called “the Penine Chain,” which separate like a “backbone” the coal-fields of Lancashire and Cheshire on the one hand from those of Derbyshire and Yorkshire on the other. These hills are composed of Carboniferous limestone and Millstone grit, the basement series of the Coal-measures; and no one familiar with the similarity of the strata on either side of this dividing ridge can doubt for a moment that the strata of which the ridge is formed were originally overspread by deposits of coal-bearing strata. Equally certain is it, that a large portion of the Carboniferous limestone of the central plain of Ireland was once overlaid by coal deposits; but they are gone, as are those of the Penine Chain in Derbyshire; and in both cases they have disappeared through the agency of “denudation,” a term by which we express the removal of masses of strata, by the agency of rivers, seas, and other forms of water at distant periods of the earth’s history.

Denudation, then, has despoiled Ireland of her mineral resources, and for all time has moulded the character of her inhabitants. Who can say, how different might have been her history had an abundance of mineral wealth stimulated the natural genius of her sons, and rendered her the centre of mining and manufacturing industries!

From these speculations let us now turn to the consideration of

those mineral resources which still are left. Commencing with the most important—namely, coal—we find that there are the following coal-fields, some of which are to be regarded, however, as almost worthless, as far as our information extends:—

1. County Clare (Connaught Coal-field). 2. Kerry and Limerick (Munster Coal-field). 3. Tipperary and Kilkenny (Leinster Coal-field). 4. Leitrim and Fermanagh. 5. Meath. 6. Dungannon, co. Tyrone. 7. Ballycastle, co. Antrim. Besides which, there are several small tracts of unproductive Coal-measures.

1. *Co. Clare*.—This coal-field is only partially explored. It extends from the north bank of the estuary of the Shannon to an apex a few miles south of Galway Bay, and from the Atlantic coast inland nearly as far as Ennis. It contains several seams of coal, the thickest being about 30 inches, as also bands and nodules of clay-ironstone. The following section by Messrs. Kinahan and Foot, of the Geological Survey of Ireland, gives a general view of the succession of the strata where they occur in greatest thickness: *—

GENERAL SECTION—COUNTY CLARE.

	Ft.	In.
8. Shales principally—thickness uncertain.		
7. Money Point-flags	150	0
6. Shales principally	200	0
COAL	1	6
5. Intermediate beds, about	600	0
COAL	2	6
4. Intermediate beds, about	700	0
COAL	0	6
3. Grits and shales, about	930	0
2. Lower flagstone series, about	70	0
1. Shale series, about	500	0
	3150	0

2. *Kerry and Limerick*.—This coal-field is a continuation to the south of the estuary of the Shannon of that which has just been described. In proportion to its enormous extent, it is far from productive. At Coal Hill and Knocknaboola collieries, situated near the banks of the Shannon, seams varying from 6 inches to 3 feet have been worked, but only to a small extent. The seams are either anthracite or culm, and appear to be of very limited range.† In other parts of the district, according to Professor Jukes, the coal-beds are often highly inclined, contorted and compressed, so as to be only a few inches in thickness for many yards, and then suddenly expand into large pockets of coal of a thickness of 20 or 30 feet; under these conditions the coal is sometimes extracted in the manner of working metallic lodes.

* 'Explanation of Geological Survey Map 142,' p. 9. 1860.

† For an account of these coals, and the mode of working, see 'Explanation of Geological Survey Map 142,' by Mr. Kinahan, p. 36.

Clay-ironstone was formerly extensively worked from the shales which overlie the uppermost coal-seam, both at the Rock Colliery and south-east of Glin. Here there was a furnace for smelting the ore, but the ironstones are generally too poor in quality and too small in quantity to make them of any economic value.

3. *Tipperary and Kilkenny*.—This is one of the most important coal-fields in Ireland, and has been ably described by Sir R. Griffith, in his 'Report on the Leinster Coal-field,' and more recently by the officers of the Geological Survey.* The coal is of three varieties, known in the district as *anthracite*, *culm*, and *kelve*. Of these the anthracite is the most valuable, and the kelve the least, being merely a carbonaceous ferruginous shale, with so much combustible matter as to be used for fuel. The culm is extensively used for brick-making and lime-burning; and the anthracite, which is generally highly pyritous, when ignited gives out an intense heat. The following is a general section of the strata of this coal-field in its thickest part:—

GENERAL SECTION NEAR CASTLECOMER.

	Ft.	In.
Uppermost strata	12	0
Peacock coal	1	10
Intermediate strata	45	0
STONY COAL	3	0
Intermediate strata	21	0
Double seam of coal (partly fireclay)	5	0
Intermediate strata	120	0
Three-foot seam of coal	3	0
Intermediate strata	180	0
Foot coal	1	6
Intermediate strata (about)	300	0
Gale Hill coal	0	6
Flagstone series (about)	650	0
Black shale series	500	0
Carboniferous limestone.		

The lowest seam of coal is not workable, but the "foot" and "three-foot" seams have a considerable range, and have been largely worked. The uppermost seams occupy only a very limited area, as they have been denuded from off the greater portion of the coal-field. Along with the seams of coal are several beds of clay-ironstone of fair quality and thickness. These were once mined and smelted at Moyhora and Lacka, in the Queen's County. In the deep workings at Massford, and at Coolham Hill, Moyhora, Moyadd, and other places, the old workings were on an extensive scale.† This coal-field possesses sixteen collieries now at work.

4. *Leitrim and Fermanagh*.—This coal-field is of considerable extent, lying to the north of, and around, the shores of Lough Allen. It contains several seams of coal, at least two of which are workable,

* 'Explanation of Geological Survey Map 137,' by Messrs. Jukes, Kinahan, and Du Noyer. 1859.

† Mr. G. H. Kinahan's 'Explanation of Geological Survey Map, sheet 137,' p. 51.

and one of bituminous coal of fair quality, which is worked near Cashel. There are several collieries in the vicinity of Boyle and Drumkeeran. As the Government surveyors have not as yet entered upon the examination of this district, we are as yet only partially acquainted with its mineral resources.

5. The little coal-tracts of the county Meath are also only partially explored, but it is well known that the beds of coal are of very limited extent.

6. *Dungannon*.—The area of this coal-field does not exceed twelve square miles, only part of which is productive of coal; but as compared with the coal-tracts we have been considering, it is comparatively rich in minerals, which have been examined and described in detail by Sir R. Griffith.

Unlike the coal-fields of the south and west of Ireland, which are on every side bounded by the Carboniferous limestone or the Atlantic Ocean, the Tyrone coal-field is bounded to the south and east by the New Red Sandstone formation, below which the seams of coal may be considered to dip, and to be within reach of mining operations. The coal-field is divisible into two districts, namely, that of Coal-Island and Annahone: the former, according to the estimate of Sir R. Griffith, has an area of about 7000 acres, and the latter over 300 acres. The general section in its deepest part is as follows:—

SECTION OF THE TYRONE COAL-FIELD.

	Ft.	In.
<i>Upper coal</i> (impure)	2	2
<i>Intermediate strata</i>	37	0
<i>Annaher coal</i> (soft)	9	0
<i>Intermediate strata</i>	55	0
<i>Bone coal</i>	3	0
<i>Intermediate strata</i>	39	0
<i>Shining coal</i>	2	10
<i>Intermediate strata</i>	78	0
<i>Brackaveel coal</i> (good quality)	4	6
<i>Intermediate strata</i>	74	0
<i>Baltaboy coal</i> (sulphurous)	3	0
<i>Intermediate strata</i>	72	0
<i>Gortnaskea coal</i> (partly cannel)	6	0
<i>Intermediate strata</i>	225	0
<i>Derry coal</i> (good quality)	4	6

Below these are several other seams, and as a general rule the coal of this district is of fair quality, and is associated with several beds of ironstone and fireclay.

To what extent this coal-field underlies the flat tract of ground which stretches eastward to the banks of Lough Neagh, and southwards to the banks of the river Blackwater, is a question of economic importance remaining to be solved. It is to be hoped that beds of coal, of such value both as regards thickness and quality as to resemble those of several of the English coal-fields,

will be ultimately found like them to extend far beneath the Triassic strata, and to become a source of industry and wealth to the country around.

7. *Ballycastle, Co. Antrim.*—This isolated coal-tract extends along the southern shore of Ballycastle Bay to Fair Head, and southward to Murloch Bay. It is of small extent, the strata reposing on a floor of crystalline schists, and being surmounted by a sheet of columnar basalt, which is visible along the fine cliff of Murloch Bay. There are (or rather were) several good seams of coal, which appear to have been worked from very early times, the old passages and chambers having been unexpectedly discovered by the miners in the year 1770. The coal is now, however, nearly exhausted, but there still remain at least two seams of "black-band" ironstone, which are now being worked, and exported to the smelting furnaces belonging to the firm of Messrs. Merry and Cunninghame, in Ayrshire.

The above concludes our review, necessarily brief, of the coal-fields of Ireland. It will be apparent that, in a national point of view, the extent of their resources is altogether unimportant. Perhaps the largest proportion of the valuable seams of coal have already been worked out, and with the exception of the district of Dungannon, it is clear that even the local demands of the country must be supplied from British sources of supply. In the absence of coal, peat is the kind of fuel upon which the population of the country mainly depends; fortunately the supply of this is almost unlimited, and is to some extent being constantly restored by new growths as the process of extraction proceeds.

In 1868 there were about thirty-four collieries, often of small size, in work, producing 126,950 tons of coal, as appears from the "Mineral Statistics" for that year.

That iron was formerly smelted from native ores to a considerable extent there is abundant evidence, both from documents and the remains of old workings in many parts of the country. During the last century much of the timber which once clothed the surface of the country, and of which the relics are to be found in every bog and morass, was felled for the supply of the iron-furnaces, some of which survived into the present century. The superior resources of the Welsh, English, and Scotch iron-fields effectually terminated smelting operations in the sister-isle; nor are they likely to be resumed.

The chief source of this metal was the clay-ironstone of the Coal-measures; but there was a large quantity obtained from bog-iron-ore and hæmatite. A new source has lately been opened up in the province of Ulster. A band of ochreous ore underlying the basalt of county Antrim is now worked along the northern shores of Belfast Lough, and is exported to Scotland.

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As regards the remaining useful metals, it is only necessary to mention that ores of lead, zinc, copper, silver, and native gold occur in various parts of the country, especially in the counties of Wicklow, Waterford, Tipperary, Monaghan, Kerry, Galway, Dublin, Donegal, Cork, and Clare. We have only to cast our eyes over the catalogue of localities where mines, or metalliferous veins have been discovered, published by the General Valuation Office, under the superintendence of Sir Richard Griffith, to be assured that the country is rich in minerals, only partially developed. Beds of rock-salt have been recently discovered near Carrickfergus, and gypsum near Kingscourt, in county Meath. Nor in this brief summary of the mineral resources of Ireland may we omit to mention—the encrinital marbles of Galway, Cork, and Dublin; the granites of Wicklow, Down, and Galway; and the rich serpentinous marbles of Connemara.*

* For an account of the mines of the county Wicklow the reader is referred to the 'Records of the School of Mines,' vol. i., part iii., by Mr. Warrington W. Smyth, F.R.S. (1853); and for the districts of the south and west of Ireland, to the 'Explanations of the Geological Survey Maps,' published by the Geological Survey of Ireland.

CHRONICLES OF SCIENCE,

Including the Proceedings of Learned Societies at Home and Abroad;
and Notices of Recent Scientific Literature.

1. AGRICULTURE.

A good harvest month has somewhat improved the grain produce of the year, which, however, as regards the wheat crop, is considerably below the average, and very much inferior to our experience of last year. The great agricultural meeting at Manchester has given to our leading manufacturing population a better idea than they before possessed of the real status as well as of the relative position of the food manufacture among the other manufactures of the country. So admirable a collection of specimen products, and especially of our various breeds of live stock, was never before exhibited; and the immense collection of agricultural machinery, which Manchester spectators most of all were likely to appreciate, could not fail to give the impression that the agricultural body had contributed quite their share to that ideal of energy, promptitude, practical ability, and success to which we give the name—John Bull.

In the Parliamentary session just closed two important agricultural measures have been enacted, one of which assumes, properly enough, that English farmers cannot take care of themselves; of the other, differences of opinion on this point exist. The former lays certain restrictions on the trade in foreign live stock, providing for such a separation or quarantine of imported animals as shall hinder the introduction of infectious diseases; the latter inflicts penalties on any one who shall kill or dye seeds for fraudulent purposes. The practice had become notorious, and called for remedy: but it is believed by many that the true remedy is already in the hands of the farmer, and needs no legislative supplement. Better teach a great community, whose ability is so well illustrated by every agricultural meeting, the art of taking care of themselves, than surround them with enactments for their safety.

The analysis of manures, however, much more than the analysis of seeds, has long been known as an efficient protection against fraud in the artificial manure market; but it appears now that a guarantee by the chemist of so much per cent. of soluble phosphate cannot be depended on for any length of time. Soluble phosphates do under certain circumstances fall back into their original chemical condition by mere lapse of time. And a recent trial proves that twenty-four per cent. of soluble phosphate may in a few weeks become eighteen or nineteen per cent. without any

taint of dishonesty attaching to either salesman or warehouseman. Other phosphates besides those of lime are now used in the manufacture; and thus use as much sulphuric acid in their conversion as you will, a portion of the phosphate which it makes soluble in water becomes in time insoluble in water—reprecipitated, as it were, in the substance of the superphosphate itself, or in other words, it is again reduced. After all, however, the effect of the original solution is not entirely lost; the process which thus prematurely takes place does in every case ensue upon the addition of a superphosphate to the soil; and it is the finely divided condition of the resultant neutral phosphate in the soil, not the easily soluble condition of superphosphate which is applied to the soil, on which the immediately fertilizing power of the manure depends.

The subject of thin seeding has occupied a good deal of attention lately in agricultural journals. The practice of sowing two or even three bushels of wheat per acre seems on the face of it a monstrous waste of seed. There are thus 1,200,000 to 1,800,000 grains sown on every acre, corresponding to from 30 to 40 seeds on every square foot of ground! which is apparently absurd. And no doubt it is really wrong in the great majority of cases; nevertheless the question is one not for the arithmetician, but for the agriculturist. The object is to get the greatest possible crop; and if, as the 'Agricultural Gazette' points out, the practice of sowing 20 or 30 seeds per foot proves right during the harvest month, we can well afford to neglect the arithmetical proof of its folly and absurdity which it will receive during all the other eleven months of the year. In practice the quantity of seed sown per acre has gradually diminished of late years, and 5 or 6 pecks of wheat are now commonly sown per acre, where 8 or 10 used to be the common allowance. Among matters of personal interest which have occupied attention during the past quarter, we may name the publication of a memoir of the late John Grey, of Dilston, by his daughter, Mrs. G. Butler. It is the biography of a large-hearted and accomplished man, whose great and good influence upon agricultural progress it will materially help to maintain. The labours of Mr. W. Smith, of Woolstone, as the pioneer of steam cultivation, have been the subject of discussion and recognition. The visit of M. Dumas, the distinguished French chemist, to this country, and notably to the experimental farm of Mr. Lawes at Rothamsted and to the sewage farm at Barking, deserves a record for the attention which was directed by it at once to the long-continued and most valuable labours of our great agricultural chemists, Messrs. Lawes and Gilbert, in the domain of agricultural theory, and to the leading question in the field of agricultural practice, which is receiving so satisfactory a solution in the hands of the Metropolis Sewage Company.

2. ARCHÆOLOGY (PRE-HISTORIC),

And Notices of Recent Archæological Works.

It is now five years since Professor Owen read before the Royal Society the first part of his paper "On the Human Remains from the Cave of Bruniquel." Early in the present year he communicated the second part, containing the account of the Equine remains.

This cavern, situated in a limestone cliff on the north side of the valley of the Aveyron, Département Tarne et Garonne, was explored by its proprietor, the Vicomte de Lastic St. Jal, in 1863, and a suite of the remains (selected by Professor Owen) were secured by the Trustees for the British Museum.

Although this deposit is chiefly rich in remains of the Reindeer and Wild Horse—both these animals having been eaten in great numbers by the ancient denizens of the cavern—there is here a total absence of the remains of the Cave-lion, Cave-bear, Hyæna, and those large extinct pachyderms that have elsewhere been found in ossiferous deposits.

Of the existence of early man in Western Europe with the Mammoth, Rhinoceros, Hyæna, &c., there can now be little doubt; but at the time when he occupied the caves of Dordogne and the Aveyron, and left behind, in the hearth-stuff of these caves, such indubitable evidence of his long-continued residence, the larger pachyderms and more formidable beasts of prey had apparently given place to vast migratory herds of Reindeer and Wild Horses, upon which the Cave-men subsisted, and of the bones and horns of which their weapons of the chase were made.

The mammalian fauna of such caves as Kent's Hole, Torquay, or Genista Cave, Gibraltar, may be more varied and remarkable, but as regards the excellence of the drawings of animals on some of the bones, the fine workmanship of the barbed harpoons and bone needles, no cavern has yielded a better or finer series than that of Bruniquel.

We shall look forward with much interest to the publication of Prof. Owen's valuable paper in the 'Philosophical Transactions.'

In some notes "On the Sutherland Gold-field," by the Rev. J. M. Joass, communicated to the Geological Society by Sir Roderick I. Murchison, Bart.,* the author refers to the Pictish Towers, a class of ancient buildings very numerous in Sutherland, and specially abundant within the ascertained auriferous district. These towers, wherever they occur, from Shetland to the south of

* See 'Quart. Journ. Geol. Soc.,' vol. xxv., pp. 317-326.

Inverness-shire, appear to be associated with rocks which may be more or less auriferous—namely, the Lower Silurian.

These forts have no doubt been erected against maritime invaders. Their number and strength suggest the frequency and formidable nature of such inroads, for which a motive may be found in the supposition that south-eastern Sutherland and other districts where such duns or burgs occur, were known in pre-historic times to be rich in gold or other mineral treasures.

Hence, perhaps, the connection between the copper of Sandness and Mousa-burg, in Shetland; the lead and silver of Beaufort and Struidh-burg, in Inverness; the gold of Durness and Dun-Dornadilla, in west Sutherland; of Uisge-dubh and Caisteal-Coille; of Allt-Smeorail with Aschoille-burg on the one side, and Coir-Aoiscaig tower on the other; and of Strath Ullie, with its chain of Pietish strongholds from Dun-uaine on the coast to the wonderful group of Cyclopean structures that crown Beinn-Ghriam-beg, twenty-eight miles inland.

Hence too, perhaps, the origin of the native torques and armillæ of beaten gold, attractive booty no doubt to the roving Norsemen, "the extractors of rings"; and hence, also, it may be, one reason why the largest nugget lately found weighs only 2 oz. 17 dwts., if we suppose that the gold discoverable without washing or other modern appliances had been picked up by the pre-historic people.

Mr. George Anderson lately communicated to the Geological Society of Edinburgh an interesting description of Craig Phadrich, a vitrified fort near Inverness. This pre-historic fortress occupies the termination of a rocky ridge (about 250 feet in height) in the long chain of mountains which skirt the west of the great glen of Scotland, and fronts the Ordhill of Kessock, another vitrified fort on the opposite Ross-shire coast.

It forms the advanced beacon-station on the Moray Firth, from which signals could be passed by each successive link of the chain of natural telegraph-stations stretching far into the recesses of the country beyond the head of the Beauly Firth, in Ross-shire, Glenstrathfarar and Strathglass, as well as in the great glen.

Six or seven vitrified summits are visible from Craig Phadrich, and if the ordinary hill-forts, having huge ramparts of stone round their tops, belong to the same period, that number might be nearly doubled. Craig Phadrich stands on a hill of Old Red Sandstone, capped with a mass of hard conglomerate, with precipitous faces on the north and south sides, and steep ridges of approach on the east and west. These approaches were guarded by two walls or embankments—one, a very strong and high one on the summit, composed of loose stones, sand, and gravel—the other about 50 feet lower down the slope, less massive but much more highly vitrified. The pathway up the western side is extremely narrow and tortuous, and

flanked by projecting masses of rock, from which loose stones could be readily hurled on an invading foe. The eastern ascent is the main approach, but the entrance is so strongly fortified by projecting walls or bastions that it could readily have been defended from above.

In the upper rampart the vitrified stones occur intermixed with others not affected by fire, and with loose sand and gravel. In the lower, or outer wall on the south side, the fusion has been much more complete, pieces of granite, gneiss, mica-slate, and quartz-rock, with some bits of sandstone, being all fused together. Mr. Anderson observed long strings of vitrified matter which had poured down from the melted mass above among the loose materials beneath.

The writer has carefully examined similar vitrified forts in the Sidlaw Hills, overlooking the valley of the South Esk.

Bearing in mind the infusible materials of which these walls are built, it seems almost incredible that a rude and savage race should have resorted to the agency of fire to consolidate them. The heat required even to vitrify the exterior of a mass of granite must have been not only very intense, but such as would endure for many days. In Craig Phadrich the fusion of the walls had penetrated for 12 or 14 inches into the mass.

In the 'Natural History Transactions of Northumberland and Durham,'* the Rev. G. Rome Hall investigates the origin of certain Terraced Slopes in North Tynedale. These terraces occur in the borders of the valley of the North Tyne and the river Rede, near to the Roman Wall and Watling Street, and close to the sites of numerous British camps. They have been examined by the geologist, the military engineer, the practical agriculturist, and the archaeologist, and each, from his own particular stand-point, has traced their formation to widely different agencies. The author describes and maps upwards of seven sets of these terraced slopes: four sets near the village of Birtley; two sets near Swinburne Castle, and another series near Wall Camp Hill, &c.

The terraces of Steel Burn are 400 yards long, about seven to ten in number, and face to the south-west; another set, ten in number, are 150 yards long, and face the west. The next series are seven to eight in number, each several yards in breadth, five to seven feet in height, and face due south. Near Buteland House there are six to seven terraces, three feet in height, and many yards in breadth, facing west. Those near Birtley form nearly a rectangle, the western face being 300 yards long, the southern face 110 yards. The former has six ledges, with a shorter one inserted midway, and the lowest not parallel. The terraces average three,

* Part i., vol. iii

five, six, seven, one-and-a-half, and five feet in height, reckoning from the base; and the platforms are fourteen, eight, and the three uppermost, nine yards in breadth. The peculiarity of these ridges, as compared with ancient river-terraces, is their want of parallelism, their disagreement in relative levels, and their general want of correspondence with the course of the valley, as well as the fact that one set of terraces disagrees with another near it. Mr. Hall cites the opinion of Mr. G. Tate, F.G.S., in favour of the artificial, and against the geological origin of these terraces. He refers to the various theories as to the military uses to which they may have been applied, and cites Lieut. Sitwell, R.E., against their fitness as lines of defences. Finally, from independent investigation, the author has been led to the conclusion that we have here the early attempts at cereal cultivation of the ancient British inhabitants of the valley.

The author cites numerous authorities, both ancient and modern, in favour of his theory, and we are bound to say he makes out a good case. Mr. G. Poulett Scrope has given this explanation to terraces in Wilts and Dorset, and shown that these "Linchets" or "Balks" are still in process of formation on farms in Wiltshire at the present day.*

In the 'Transactions and Proceedings of the New Zealand Institute,'† there is, among other interesting matter, a paper by the Hon. W. B. Mantell, F.G.S., on the "Moa."

After instancing examples to show that New Zealand was not peculiar in the circumstance that huge birds, without the power of flight, were the highest form of life previous to the arrival of man in the islands, he proceeded to describe the different circumstances under which the remains of the Moa are found, assigning the highest antiquity to those that are found under the stalagmite in certain limestone caves similar to the bone-caves in which traces of the early animals which inhabited Great Britain are preserved to us. He drew attention to the fact, that in the British caves, among the great variety of animals represented, there is always evidence that they were dragged into these caves by beasts of prey; but New Zealand caves have failed to show any such cause for the presence of the Moa-bones in them, or that any animal existed beyond larger forms of those now inhabiting the islands. These cave Moa-bones, and probably those found in certain alluvial deposits, he considered to belong to a period before the arrival of the aborigines. He then described the several circumstances under which the remains of the Moa are found associated with works of man, in such a manner as to leave no doubt that they co-existed with the earliest aborigines, and were largely used as food, along

* See 'Geol. Mag.,' vol. iii., 1866, p. 293.

† Vol. i. (issued May, 1869).

with seals and a variety of other animals. From the examination of the *umus* or Maori ovens, there was evidence that cannibalism prevailed at the time the Moas were used for food, but only in the North Island. Certain works of art associated with bones in these early deposits appear to indicate a period when many of the implements in common use among the Maoris, and supposed to have been brought with them from Hawaiki, were unknown to these early aborigines. The highly-prized Ponamu, or Greenstone, appears also to have been discovered in New Zealand at a later date. The most ancient of the native ovens which he had examined were scooped out in the surface of marine deposits, generally blue-clays or sands, such as are deposited in estuaries or tidal lagoons, and never covered by other than fresh-water or blown sand deposits.

Those at Wainongaro, in the North Island, and at Awamua, in Otago, were the oldest he had seen, and contained fragments of stone used as cutting implements, of kinds that showed that even at that early period the natives had extensively explored the interior of these islands. In Otago, especially, it is probable that the interior was their usual dwelling-place, and that they only paid occasional and periodical visits to the sea-coast. He referred to certain rude figures which he discovered drawn on the walls of a cave in the Waitaki valley, among which was rudely depicted the likeness of a Moa, by some early aboriginal artist, and proceeded to describe the causes which led to the extermination of those birds. This must have taken place within a very short period after the appearance of man, adducing the very slight and obscure allusions in the most ancient Maori traditions to their existence as proof of this.

After alluding to the probable habits and mode of life of the Moa, and to the present representatives of the class of bird to which they belong, Mr. Mantell concluded by saying that in his lecture he confined himself to the subject of the Moa, the native word including these birds as a whole, leaving the different species of *Dinornis*, *Palapteryx*, and other genera which have been made, to those who believe that they have the necessary data; for his part, he did not believe that, with the exception of the very fresh skeleton found in Otago, and now in the York Museum, of which the integument and feathers are partly preserved, there was yet a single skeleton restored in such a manner as would be at all suited to the wants of the bird if it were alive; he therefore strongly urged the careful collection of specimens, and that those persons who discovered bones, if they did not consider themselves well acquainted with the subject, should leave them untouched until they could be exhumed by properly qualified collectors.

In Dr. Foster's 'Mississippi Valley,'* the author gives an

account of the extent and distribution of the relics of the ancient "Mound-Builders," a race which, long antecedent to the North-American Indian, once occupied the region of the Great Lakes and the Valley of the Mississippi. The trees which covered these mounds when first discovered by the white settlers, differed in no degree, either of size or form, from those of the surrounding woods. The late Professor Hitchcock, without examination, denied their artificial origin, but subsequent investigations by the geologist and the antiquary, side by side, have proved beyond a doubt that they were formed by human hands. Evidence afforded by the earth-works has also connected their builders with the ancient copper-miners of Lake Superior, whose operations represent probably the most extensive pre-historic mines in the world.

Dr. Foster points out that the number and magnitude of these earth-works not only indicate a vast population, but also a people subsisting by agricultural pursuits; as no mere nomadic race, subsisting by the chase, could have devoted the time necessary for the formation of such extensive national works. The earth-work at Cahokia, Illinois, is 90 feet high, and has a base of 666 feet; while the famous mound at Grave Creek, Virginia, is 70 feet high, with a base of 333 feet; and the next in rank is that of Miamisburgh, Ohio, which is 68 feet high, with a base of 284 feet.

Near Newark, Ohio, the circles, squares, parallel roads, and tumuli, extend over many leagues of ground, and out-rival, in cubical contents, the great Pyramid of Cheops.

Their weapons were spear and arrow heads, chipped with much skill, out of hornstone or chert; hammers, generally of porphyry, grooved near the head for the attachment of a withe; fleshing instruments of the same material, brought down to a blunt edge; pestles for cracking and grinding corn; plates of steatite, or chlorite slate, pierced with holes to gauge the size of the thread in spinning; circular discs, like weights, and concave on both sides, ordinarily of porphyry and ground; ornaments like plum-bobs, double-coned, or egg-shaped, and pierced or grooved at one end for the attachment of a string made of specular iron, like that of Lake Superior; lastly, elaborately-wrought pipes, showing that they indulged in the luxury of tobacco.

They mined extensively the native copper on the shores of Lake Superior, and wrought it into knives, spear-heads, chisels, bracelets, and other personal ornaments.

They were unacquainted with tin, and had no alloy; and there is reason to believe they did not, even ordinarily, smelt the copper, but simply *hammered it cold*.

Bracelets of copper have been found in the mounds, enclosing native silver in the unaltered state as it occurs in the mine.

They had also made considerable advance in the ceramic art,

many of the specimens of pottery discovered displaying considerable taste and skill.

Dr. Foster concludes that the Mound-Builders were an industrious, peaceful, and numerous race, pursuing agriculture as a means of support, maize being their staple article of food; ruled over by a despotic government, under whose direction their great public monuments were carried out; and lastly, that their extermination has resulted from the invasion of a less civilized but more vigorous and warlike people.

3. ASTRONOMY.

(Including the Proceedings of the Astronomical Society.)

THE successful observation of the eclipse of August 7th is a fortunate circumstance for science, because it is not likely that either of the two next total eclipses (in 1870 and 1871) will afford a favourable opportunity for observations of the coloured prominences. The eclipse of 1872 will last but a few seconds as a total eclipse, and will only be visible as such over parts of the South Pacific.

The observations made by the American astronomers leave little to be desired. The photographs which have been obtained will probably be the best which have hitherto rewarded the exertions of astronomers in the particularly difficult art of celestial photography. Major Tennant at Guntoor, and the German observers at Aden, last year obtained remarkably good photographs of the eclipsed sun; but the intense heat of the Indian climate added largely to Major Tennant's difficulties, while the observers at Aden had to photograph the prominences soon after sun-rise, when their light was received through the denser atmospheric strata. In the United States all the circumstances were highly favourable; and from the known skill of the American astronomers in the art of celestial photography, we may hope for results of the utmost importance and scientific value. It is seldom that an eclipse visits astronomers so near their own home as this one did, its track lying close past several of the leading American observatories.

The most interesting result of the observations, so far as our information as yet extends, is the discovery that the spectrum of the prominences contains several lines more than had hitherto been discovered. M. Rayet last year discovered eight, but some doubt was thrown on his observations by the fact that none of the other astronomers engaged in the spectroscopic analysis of the prominences saw so many lines. Professor Winlock, observing the recent eclipse at Shelbyville, Kentucky, saw no less than eleven bright lines.

Thus we may infer that the structure of the prominences is more complex than had hitherto been supposed. It is to be hoped that the new lines, and possibly others, may admit of being rendered visible by the spectroscope without the aid of an eclipse. Possibly when Mr. Huggins' new telescope is at work, we may learn the position of the newly-discovered lines in the accurate manner which the particular mode of observation we refer to renders possible. It would be interesting to discover what are the elements to which the lines belong.

The darkness during the eclipse was much greater than during the eclipse of last year, though the totality did not last so long by nearly three minutes. Some of the observers searched, but without success, for intra-Mercurial planets.

Although Professor Tyndall's recent investigations of the phenomena presented by comets are too closely associated with his physical researches to be described in full in our astronomical Chronicle, yet there are certain points connected with his new theory which it belongs especially to astronomy to deal with.

Passing over the physical considerations on which the theory depends, and which serve to distinguish it from most of the hypotheses hitherto put forward (based as these are on no known experimental laws), we may describe the theory as follows:—

The tail of a comet is not matter projected from the head, but matter precipitated on the solar beams which have traversed the head. Tyndall has shown that such precipitation may occur either with comparative slowness along the beam, or with the velocity with which the beam actually traverses space. Thus the amazing rapidity with which a comet's tail is sometimes developed is accounted for "without invoking the incredible motion of translation hitherto assumed."* As the comet sweeps round the perihelion, the tail is not composed of the same matter, but new matter is precipitated on the solar beams, the part of the old tail which is not protected (so to speak) by the head of the comet being dissipated by the sun's calorific rays; and the dissipation not being necessarily instantaneous, "the tail leans towards that portion of space last quitted by the comet—a general fact of observation being thus accounted for." Occasional lateral streamers are explained as possibly due to the temporary mastery of the actinic rays in parts of the cometary atmosphere not screened by the nucleus. Lastly, the shrinking of the head as the comet approaches the sun is due to the beating of the heat-rays against the attenuated fringe of the head, which is thus dissipated.

Although the theory, as at present put forward, fails to account

* Here, in passing, we may notice that Professor Tyndall is in error as to the opinions received among astronomers, for Sir John Herschel long since proved that no such assumption is permissible.

for many of the observed peculiarities of comets, yet it appears to us not unlikely that a way may yet be found to reconcile the strange phenomena which some comets have presented with the views maintained by Professor Tyndall. We cannot at present admit his explanation of lateral streamers, because it leaves us in quite as much perplexity as we have ever been in with respect to this strange phenomenon. When we see a tail extending in a right line from the head, but at an angle of 60° or so to the radial line from the sun, we require more to account for the peculiarity than the bare possibility that along that line the actinic rays may temporarily have obtained the mastery; and when we see, as in the famous comet of 1774, six distinct tails spreading from the head in the shape of a fan, it is yet more unsatisfactory to refer to a mere possibility of this sort. Professor Tyndall mentions no illustrative case as having occurred in the course of his experiments on actinic clouds; and therefore, so far as this part of his theory is concerned, he seems scarcely justified in saying that "throughout he has dealt exclusively with true causes," and that "no agency has been invoked which does not rest on the sure basis either of observation or experiment."

However, the great difficulty in cometic phenomena, the apparent swinging round of the tail with a velocity often far exceeding the greatest velocity possible within the solar scheme, is undoubtedly mastered by Professor Tyndall's theory; and this circumstance renders us hopeful that he may be able to find a more satisfactory explanation than he has yet given of *abnormal* cometic phenomena.

The application of the enormous heat-gathering powers of the great Parsonstown reflector to the solution of the long- vexed problem of the moon's heat, is one of the most valuable results which have followed the construction of clock-work suited to drive this great telescope. The question is one of such extreme delicacy, that so long as the telescope had to be guided by the old arrangement no results of a satisfactory nature could be hoped for. On the other hand, no other telescope could be applied to the work with reasonable chance of success. Mr. Huggins had detected no sign of heat, when the moon's rays were gathered by his powerful refractor upon the face of a delicate thermopile; and indeed Professor Tyndall long since pointed out that it was almost hopeless to apply a refractor to such work, the moon's heat being of such a nature that far the greater part must be absorbed by the object-lens. With the Rosse telescope (used in combination with a delicate thermopile), clear signs of heat were detected, and thus at length the question has been set at rest.

Comparing the heat received from the moon with that derived from several terrestrial sources, Lord Rosse has deduced the conclusion that at the time of full moon a part of the moon's surface

may be heated to a temperature of more than 500° Fahrenheit. We have no particulars, however, as to the reasoning which led the observer to the conclusion that most of the heat we receive from the moon is radiated towards us. May not the majority have been reflected? The distinction is all-important, so far as the views we are to form of the temperature of the moon's surface are concerned.

The planet Jupiter will be well placed for observation during the next quarter. Saturn is passing away from our skies.

Judging from the wide region over which the November meteors were seen last year, there is every reason to believe that they will be well seen in England this year, on November 14th, in the morning hours, though probably the shower will not be comparable with that of 1866.

PROCEEDINGS OF THE ASTRONOMICAL SOCIETY.

Mr. Plummer has been able to confirm Mr. Huggins' spectroscopic observations of the Auroral streamers. He notices that the line in the Aurora spectrum agrees closely with the most conspicuous of the lines in the spectrum of Betelgeux, between the solar lines D and E. There is also a tolerably conspicuous line in the spectrum of Aldebaran near the same place. A conspicuous line in the spectrum of air is near the line seen in the spectrum of Aurora, but not near enough, in Mr. Plummer's opinion, to suggest the possibility that the want of coincidence is due to an error of observation.

Mr. Plummer noticed further that Winnecke's comet was visible with the 6½-inch refractor of the Durham Observatory, through one of the densest streamers, "without any other inconvenience than that of the brightness of the field of view.

Commander Ashe, R.N., sends an interesting account of his determination of the position of "Rivière du Loup," by electric telegraph. The place is about 130 miles below Quebec. Commander Ashe took advantage of the intense cold then prevailing in Canada, to obtain a firm stand for his transit instrument. He got a flour-barrel, removed the snow from the earth, and placed the barrel on the ground, then filled it with sand, poured two or three buckets of water over it and around it, and, as it was freezing, placed a square piece of board on the top. In a few minutes the whole was a solid mass, and throughout the series of observations this novel observatory continued firm and unshaken. His work was somewhat impeded by the Canadian boys, "who are of the English type," and therefore are unable to resist their propensity for throwing stones when they see a light; "and it is impossible to count seconds under these circumstances," adds Commander Ashe.

The deduced longitude of Rivière du Loup is 4 h. 38 m. 10-295 s.

An account of the recent transit of Mercury, as seen at Vizagapatam by Mr. A. V. Nursing Row (a Hindoo astronomer), contains some points of interest. Mr. Row and some of his friends noticed that near the middle of the transit a "wavy tint of light" darted from the upper edge of the planet. The light was occasionally disturbed, but continued visible for some time. No change of focal length or of the eye-piece employed had any effect on the phenomenon. We do not remember any instance of a phenomenon of this sort having been noticed before during a transit of Mercury. As the Astronomer Royal for Scotland remarks, it is not easy to explain the significance of so peculiar a feature.

Major Tennant supplies an interesting note on the preparations desirable for photographic observations of such phenomena as transits of Venus. He believes that this method of utilizing a transit is a very valuable one, though he considers that it should be subjected to trial before being unreservedly trusted. He remarks that a reflecting telescope with *unsilvered* glass mirrors would give comparatively little light; and still less if the image were optically enlarged. This point is of importance in connection with the question of instrumental distortion. In a Newtonian telescope, a convex or concave lens achromatized for the actinic rays might be used; or the telescope might be a Cassegrainian, an arrangement which would be more compact than the other. An "instantaneous shutter" would allow a fairly large aperture to be used, and "this having its centre-part removed would give good definition." He suggests a new mode of releasing the shutter. At Kew it is held against a spring by a thread which is cut with scissors. Major Tennant proposes that it should be retained by an electro-magnet, and that the current forming this should pass through a chronograph. Thus if an observer at a separate telescope had a break-circuit key, he could at any moment photographically record a phenomenon he saw and the instant of its occurrence.

Mr. De la Rue, remarking on Major Tennant's paper, expresses his preference for a Newtonian reflector; the heat emerging from the back of the principal mirror, when either the Cassegrainian or Gregorian forms are used, would seriously interfere, he remarks, with the success of photographic manipulations.

Both papers show the importance of a complete investigation of all the circumstances of the coming transits.

Major Tennant suggests that preparations should be made for observing the total eclipse of 1871 in the south of India. He does not comment upon the nature of the eclipse, which we should have thought little suited for the sort of observations he suggests. In South India the totality will last little over two minutes.

Mr. Baxendell discusses the nature of the corona seen round

the sun in total eclipses. He considers that the view taken by M. Faye and the Astronomer Royal (who look upon the corona as an atmospheric phenomenon) is wholly inadmissible. When "the corona is seen to the greatest advantage, no part of the earth's atmosphere within a considerable angular distance of the sun and moon receives any direct sunlight, and therefore none can be reflected from it." He considers that not merely the optical phenomena of the corona, but "an immense number of magnetical and temperature observations made in different parts of the world" can be best explained by assuming the existence of an irregular nebulous ring circulating about the sun nearly in the plane of the ecliptic, and at a mean distance of $\cdot 169$.

Mr. Joynton has presented another series of drawings of Mars to the Society. They are selected from ninety made at various times during the recent opposition of the planet. The planet has been so carefully scanned by the late Mr. Dawes, with his fine 8-inch refractor and his unsurpassed powers of vision, that one can hardly imagine what useful object an observer can propose to himself in laboriously depicting the planet as it appears under far inferior powers. Nothing but a very powerful telescope can now teach us anything new about the lands and seas of Mars.

Professor Loomis shows that Mr. Tebbutt's observations of the variation of the mysterious star η Argus may be explained by assigning to the star a period of variation of sixty-seven years, instead of the period of forty-six years obtained by Professor Wolf. According to this view, the star has now reached its true minimum of splendour, and we may probably soon expect to see it steadily increasing. According to the best observations during the past century, the star has no less than three distinct maxima of splendour—two nearly equal and corresponding to a brightness exceeding that of all stars but Canopus and Sirius, the other corresponding to the least brilliancy of a first-magnitude star. The variable has but one minimum, corresponding to a brightness somewhat less than that of a sixth-magnitude star.

Mr. Browning describes a large sun-spot which was visible on March 14th, 1869. From north to south the spot measured 14,400 miles; from west to east 19,600 miles. The umbra contained three nuclei of very unequal dimensions, arranged nearly in the form of an equilateral triangle. Two bridges crossed the spot at an angle of about 40° . These bridges presented the appearance of broken twigs, lying mostly in the direction of the bridges' length.

On May 13th, Mr. Bidder saw a spot having a bridge of an unusually attenuated shape, and spirally formed.

Major Tennant suggests certain modifications in the construction of spirit-levels. He considers that the volume of the bubble

should be large, that its density relatively to that of the fluid should be small, and that the surface common to the fluid and the bubble should have as large an area as possible. To gain these points, and to cause the temperature to have as small an effect as possible upon the length of the bubble, he proposes that the cylindrical form of level should be abandoned, and the necessary cavity be cut out of a rectangular prism of glass. He suggests mercury for the fluid and hydrogen for the bubble.

Mr. Hind supplies an important note respecting the transit of Venus in 1874. M. Puiseux, who had independently calculated the circumstances of the transit, had arrived at results somewhat different from those published by Mr. Hind in 1861. Mr. Hind has placed the re-calculation of the elements in the hands of Mr. W. Plummer, his assistant at Mr. Bishop's observatory, Twickenham, and the result is that Mr. Hind's estimates are confirmed in a most satisfactory manner.

The June number of the *Monthly Notices* was not published by the Society's printers until the middle of August, nearly six weeks after the proper time. It contains six large maps by Mr. Proctor, illustrating a paper on the transit of Venus. Of these, four represent the same features which had been exhibited in the Astronomer Royal's maps accompanying the December number of the *Notices*, and show the effects of changing the phase from the passage of Venus's centre to the planet's internal contacts. The other two are enlarged drawings of the features exhibited in our last number. The corrections resulting from the former set are new, and some of them, if established, would seem to be important. Thus Crozet Island, which had been rejected on account of the low elevation of the sun there at ingress, is shown to have the sun $5\frac{1}{2}$ degrees higher than had been supposed. The calculated solar elevation of $4\frac{1}{2}$ degrees at Bourbon Island is altered to $12\frac{1}{2}$ degrees; 6 degrees at Mauritius to 14 degrees; and $11\frac{1}{2}$ degrees at Rodriguez to 19 degrees. These numbers all refer to ingress. As respects egress, the most important change is from a calculated solar elevation of $11\frac{1}{2}$ degrees at Chatham Island to one of 16 degrees. A number of Indian stations before unnoticed are shown to be among the best available places for observing the retarded egress.

Professor Brayley supplies an interesting paper on the nature of the bridges of light seen across solar spots. He looks upon these as the upper termination of vorticose flames.

Mr. Stone gives a table of the probable errors of Greenwich observations in zenith distance, estimated merely by their discordances from the separate means. More than 2000 observations were employed in obtaining the errors. The probable error ranges from $0''\cdot47$ at the zenith to $0''\cdot60$ half-way between the zenith and the horizon; thence to $0''\cdot70$ at an elevation of 35° above the

horizon; to $0''\cdot80$ at an elevation of 25° ; to $0''\cdot95$ at an elevation of 15° ; $1''\cdot20$ at 10° ; $1''\cdot92$ at 5° ; and, finally, $3''\cdot32$ at 3° above the horizon. These results are of the utmost importance in relation to the probable correctness of the proper motions assigned to stars which do not rise high above the horizon of Greenwich.

Mr. Browning describes a remarkably simple form of star-spectroscope. It is for direct vision, and weighs only about 7 ounces, or much less than an ordinary micrometer, so that it will scarcely at all affect the balance of a telescope.

4. BOTANY AND VEGETABLE PHYSIOLOGY.

The Antheridia of Ferns.—Dr. Kny, of Berlin, records some interesting observations on the development of the Antheridia in Ferns, which has hitherto received several distinct explanations, in spite of its apparently simple character. Cells of the form of closed rings have hitherto been observed only in the full-grown frond of several species of *Aneimia*. Concerning the mode of their formation there is a difference of opinion, at present unreconciled, between Hildebrand and Strassburger; but both these authorities agree in this, that the ring-cells have not been originally produced as such, but have received their peculiar form as a secondary development. In the antheridia of some species of *Polypodiaceæ* and *Schizæaceæ*, Dr. Kny has observed, as he thinks, the first example of a direct origin of ring-cells by the formation of funnel-shaped separating walls. They show at the same time that this occurrence, hitherto entirely isolated in the vegetable kingdom, admits of two modifications; since the ring-cells are separated in the one case from a hemispherical, in the other case from a bell-shaped mother-cell. Dr. Kny promises further researches in this interesting field.

Reproductive Organs of Lichens.—According to M. Famitzin, the Gonidia of Lichens—that is, the spherical cells filled with chlorophyll which are dispersed in the parenchyma of the frond—if maintained in a condition of sufficient humidity on the surface of bits of bark during several months, will give rise in their interior to zoospores; that is, to uniform corpuscles provided with definite movements by vibratile cilia like the zoospores of *Algæ*.

Spectroscopic Examination of Diatomaceæ.—Mr. H. L. Smith* has confirmed the vegetable nature of Diatoms by the application of the spectroscope. He has proved the absolute identity of chlorophyll or the green endochrome of plants, with diatomin or the olive-yellow endochrome of the diatoms, by the identity of their spectrum, which is a very remarkable one.

* 'American Journal of Science and Arts.'

Fertilization of Gramineæ.—M. Bidard has been observing the fertilization of grasses. He states that their pollen does not exhibit any trace of pollen-tubes, and that self-fertilization takes place before the anthers are extended beyond the perigone. The fovilla is itself absorbed from the pollen after it falls on the stigma through the thread-like tubes which perforate it. There exist in grasses two principal phenomena which are only known as belonging to this family,—the elongation of the filaments and their extrusion from the perigone after fertilization has taken place, and the fecundation by perforation of the pollen. The heat of the breath or a ray of sunshine is sufficient to bring about the phenomena of fecundation; and the natural hybridization of grasses is impossible, owing to the exact closure of the chamber containing the fecundating organ.

Fertilization of Salvia.—A contribution towards the investigation of the phenomena attending the impregnation of plants has been made in the case of the genus *Salvia*, affording a striking instance of the natural tendency towards cross-fertilization which Mr. Darwin has pointed out. The two perfect stamens of *Salvia* contain each two anther-cells at the opposite ends of a connective which is longer than the filament itself. The arm of the connective to which the upper anther-cell is attached is longer than that which supports the lower anther-cell, this latter being in some species entirely, in others partially, destitute of pollen. The lower anther-cell projects far into the mouth of the corolla, so that when the flower is visited by the bees, which frequent it very freely, the insect necessarily pushes it aside, and causes the extremely mobile connective to rotate; the upper anther-cells thus emerge from the hooded receptacle in which they are hidden, so as to bring their dehiscing surfaces into contact with the bee, one on either side. The stigmas are not ripe till a considerably later period than the anthers, and the style being prolonged much beyond the upper anther-cells, these cannot in their rotation strike against the stigmas, nor does the bee strike them in retiring from the flower. At a later period of development, however, the style becomes bent down, so that the stigmas block up the entrance into the mouth of the corolla, and it is only at this period that the stigmatic surface becomes fully developed. When a bee laden with pollen enters a flower in which the style has assumed this position, it cannot fail to rub its back against the stigmatic surface, and thus secure the fertilization of the flower. This structure has been observed, with slight modifications, in *Salvia officinalis*, *glutinosa*, *pratensis*, *Sclarea*, and some other species.

Effects of Smoke on Vegetation.—Mr. E. Green, gardener to the Right Hon. J. W. Patten, M.P., of Warrington Hall, read at the Manchester Congress an article on this subject, which contains some useful hints for dwellers in towns. During the last twenty years

the smoke and noxious gases from the chemical works have greatly increased, and one plant and tree after another has succumbed to their baneful influence. Of forest trees and shrubs, the fir and the larch were the first to give way; then followed the *Cotoneaster macrophylla*, arbor-vitæ, juniper, Erica, and rosemary. *Berberis ilicifolia*, yew, rose, and holly are disappearing, and none of the Conifers will live more than two or three years. The sycamore and hornbeam are decaying fast; the horse-chestnut is vigorous, but the leaves are often cut by the noxious vapours; beech and lime are more healthy; ash and elm the most vigorous. Rhododendron, Aucuba, and hawthorn flourish; the oak does very well; laburnum, Syringa, willow, birch, ivy, and elder are still healthy, and the privet moderately so. Of fruit-trees the pear stands best; plum and damson moderately well; apple suffers much; also red and white currant; raspberry and gooseberry rather better, but the fruit much deteriorated in flavour. Of vegetables which do well in the summer-months, kidney-beans sometimes drop off early in October; cauliflower and broccoli do not stand any frost; and even the common winter greens are very frequently injured by the cold; cucumbers cannot be grown. One effect of the gases from the chemical works is to make vegetation far more susceptible to cold; the trees, even when healthy, cast their leaves six weeks earlier than in the country districts. The greatest amount of injury occurs when the atmosphere is heavy and foggy, with scarcely a breeze; the young foliage being sometimes found cut and blackened in a straight line, as if by frost; when the wind is from the west it does more damage than when in the east.

Action of Ether on Plants.—Dr. Masters states that if a drop of ether is placed gently on the leaves of the sensitive plant, *Mimosa pudica*, it produces an anæsthetic or paralyzing effect, rendering them insensible to subsequent contact. If, however, the ether impinges on the leaf with force, or is allowed to drop from a considerable height, contraction of the leaf immediately ensues, the impact of the falling drop counteracting any paralyzing power. Experiments of a similar kind on other plants resulted in the death of the leaf or of the whole plant, or in causing the leaf to curl up along its under-surface.

Anniversary Address to the Linnean Society.—The usual anniversary address by Mr. Bentham, the President of the Linnean Society, was distinguished by the declaration of the adhesion of the first English systematist to the principle of the derivative origin of species, and the close connection between affinity of structure and consanguinity of descent. The portion of the address devoted to botanical science was chiefly occupied by a discussion of the means of dispersion of plants, the theory of stores of buried seeds, and the characteristics of dissevered species.

Mr. Bentham believes that too much stress has been laid on the structural appliances for the dissemination of seeds, and too little on the external means of transportation by birds, &c. Among *Compositæ*, several species of *Eclipta*, *Elephantopus*, *Anthemis*, and *Lapsana*, the fruit of which is destitute of pappus, have a much more wide-spread distribution than the great majority of *Senecios*. A large proportion, too, of the thistle-down which is seen floating in the air will be found on examination to have lost its seeds. It is calculated that out of every 100,000 seeds of the wild foxglove, 99,999 must perish before reaching the reproductive age. The usual explanation of the sudden appearance of new species in localities where they were hitherto unknown, on an alteration in the condition of the soil, is De Candolle's statement, "Il faut donc regarder la couche de terre végétale d'un pays comme un magasin de graines au profit des espèces indigènes." This supposition appears to rest entirely on circumstantial evidence, where direct evidence ought to be easily attainable. Though the seeds of plants which thus suddenly appear in great quantities are often by no means microscopical, as in the case of the white or Dutch clover, there is no record of a single instance in which these stores have been actually seen. Nor is there any satisfactory evidence that seeds will retain their vitality for any considerable length of time unless kept perfectly dry. Mr. Bentham would be more disposed to account for these sudden appearances by the rapid transportation of seeds by birds and other means than by the ordinary theory of stores buried in the ground for an indefinite period.

Preservation of Sub-tropical Plants through the Winter.—The mild winter of 1868–69, following closely on the remarkably fine summer of 1868, was favourable to the preservation of half-hardy plants through the winter. In the gardens of Battersea Park a number of such plants and shrubs have now been preserved for several winters by a covering of dry litter or other loose non-conducting material sufficiently thick to exclude frost. Under this treatment *Canna peruviana* and *expansa* have been preserved for two years; *Aralia papyrifera* and *Solanum laciniatum-elegans* survived last winter; while a variety of the rice-paper plant, *A. Sieboldi*, has lived through five winters, and *Echeveria secunda-glauca* has withstood 22° of frost.

Sources of Copal.—Mr. Jackson, the Curator of the Museum at Kew, has been investigating the sources of copal, an article well known to commercial men, but the origin of which has been imperfectly ascertained by botanists. Several sorts of copal are known in British trade, as the Brazilian, Indian, African, &c., the product of widely different plants. Dammar, or East Indian copal, is said to be the produce of *Vateria indica*. *Dammara orientalis* and *australis* (Coniferæ) also furnish copal from Moluccas and

Australia; while the Indian dammar is thought to be produced from *Canarium strictum* and *Shorea robusta*, and Brazilian copal from several species of *Hymenæa*. *H. coubaril* is a well-known tree in the West Indies, Brazil, Guiana, &c., exuding large quantities of a clear copal-like resin, and is probably one of the chief sources. The fruit and bark of *Trachylobium mossambicense* also contain it in large quantities, and this appears to be the source of the Zanzibar copal, and of the half-fossilized resin known in English commerce as anime. The quantity of copal exported from Zanzibar has been known to amount in some years to 800,000 lbs., valued at 60,000*l*. The fact of insects and other foreign substances being found imbedded in copal, whether recent or fossil, is easily accounted for. The tenacity of the resin when in a semi-fluid state readily entraps all bodies coming in contact with it, and it then rapidly hardens; and considering that the resin flows from the under-side of the principal branches, the fruit, flowers, or twigs of the under-growth or lower vegetation would be likely to be caught by the exuding resin and so preserved, rather than the heavy, glossy foliage of the tree itself.

Flora of the Sandwich Islands.—The flora of this group of islands was carefully investigated by the late Mr. Mann. They have a surface of about 4000 square miles, situated just within the tropics, and more than 1000 miles from any other land, except a few rocks lying to the north-west, bare of vegetation, and inhabited only by sea-fowl and seals. On this area, which includes an excessively dry and hot, a very wet and hot, and every other variety to a very dry and cold climate, is found a flora of 620 native species of flowering plants (omitting *Gramineæ*, which have not yet been fully studied) and ferns, of which the former comprise 485, and the latter 135 species. Of the 554 flowering plants, including 69 species known or supposed to have been introduced, 479 belong to *Dicotyledonæ* and 75 to *Monocotyledonæ*; and they are divided among 253 genera and 87 natural orders. Of the 554 species 377 are peculiar to the group, while 42 are of recent and 27 of supposed aboriginal introduction. Of the 253 genera 39 are peculiar, and these 39 genera are represented by 151 species, or 3·94 species to a genus, while the whole flora has but 2·58 species to each genus, thus showing the important part taken by these genera in constituting the whole phænagamous flora.

Flora of Manbhúm.—Mr. V. Ball has turned his researches connected with the Geological Survey of India to account for the benefit of botanical science, by investigating the flora of the district of Manbhúm, no collection having previously been made of the plants found in its southern portion. Instead of meeting with a realization of one's ideal of a tropical jungle, the effect produced by the vegetation is, in many parts, not strikingly different from

what we are accustomed to in England, from the park-like aspect which prevails in the higher and clearer portions; even in the valleys there are no tree-ferns nor palms, and but few orchids, mosses, or herbaceous ferns. The water and bog-plants, in particular, belong largely to European genera, as *Nymphæa*, *Drosera*, *Potamogeton*, *Alisma*, *Cyperus*, *Scirpus*, &c.; while the forest-trees are entirely different. Mr. Ball enumerates between thirty and forty of these, the timber of which is more or less valuable.

Lichens of New Grenada.—MM. Triana and Lindig have brought up the number of species of lichens in New Grenada to 467, of which 98 belong to the European flora. The saxicole species are generally more cosmopolitan than the terrestrial or corticole species; according to Nylander a large number of the European saxicole lichens inhabit also, in the tropics, the summits of mountains, while the terrestrial or corticole species are almost always more characteristic of the cryptogamous vegetation of the country which they inhabit. From New Caledonia, Dr. Nylander announces 220 species of lichens.

The Palms of Equatorial America.—Mr. R. Spruce publishes, in the 'Journal of the Linnean Society,' the results of his researches among the palms of Equatorial South America during the years 1849–1860, between 7° South and 5° North latitude, including descriptions of a large number of species not found by Martius or Wallace. Mr. Spruce's investigations of palms have led him to the somewhat singular conclusion that the hermaphrodite and self-fertilizing structure of plants is an earlier development, which has gradually advanced to the higher type of unisexuality.

Botanical Exchange Club.—In the Report of the London Botanical Exchange Club for 1868, Mr. Boswell-Syme includes much information interesting to the collector of British plants. Messrs. A. G. More and C. Bailey record the appearance of *Scirpus parvulus* on mud flats, at the mouth of the river Avoca, in co. Wicklow. The only previously recorded British habitat was near Lymington, in Hampshire, where it was believed to be extinct. *Aster salignus*, previously recorded by Miss Edmonds, from the shores of Derwentwater, appears to have been observed in that locality for the last thirty years. Mr. Boswell-Syme has revised his subdivision of *Ranunculus aquatilis*, as given in 'English Botany,' and now makes only two sub-species, *R. peltatus* and *stenopetalus*, the former including the forms *vulgaris*, *floribundus*, and *pseudo-fluitans*, the latter *heterophyllus*, *Drouettii*, and *trichophyllus*. *Mentha Nouletiana*, sent from Gloucestershire by Dr. St. Brody, appears exactly intermediate between *M. sylvestris* and *viridis*. Mr. H. C. Watson has established that the so-called *Chenopodium pseudo-botryoides* is nothing but an accidental form of *C. rubrum*. *Potamogeton filiformis*, not previously recorded from Fife, has

been detected in great abundance by Mr. Boswell-Syme, in Loch Gelly and Camilla Loch. Mr. H. C. Watson and Rev. W. W. Spicer record *Wolffia* (*Lemna*) *arrhiza* in several fresh localities in Surrey. *Phegopteris plumosa* (J. Smith) from Kew Gardens, originally from Yorkshire, is pronounced by Mr. J. G. Baker to be nothing but a very delicate finely-cut form of *Athyrium Filix-femina*. We are glad to observe that the number of members of this useful society has considerably increased during the last two years.

Botanical Appointment.—Mr. J. G. Baker, Assistant-Curator at the Kew Herbarium, has been appointed Lecturer on Botany at the London Hospital, in the place of Dr. Silver.

Death.—Dr. Chas. Jas. Meller, Director of the Botanic Gardens at the Mauritius, the companion of Dr. Livingstone in several of his journeys, died on the 26th of February, at the age of thirty-three, of fever, in New South Wales, while on a tour on behalf of the government of Mauritius, for the purpose of collecting information concerning the cultivation of the sugar-cane.

5. CHEMISTRY.

(Including the Proceedings of the Chemical Society.)

THE new earth which we announced in our last Chronicles as having been discovered by Mr. Sorby, F.R.S., in some specimens of zircon or jargon, has been submitted to chemical examination by Mr. Forbes, F.R.S., who, as a result of this examination, has published a quantitative analysis of the specimen of jargon in which the discovery was first made.

The jargon employed was in fragments, being part of an almost colourless crystal, forwarded by Mr. Sorby, who had previously found, by optical examination, that it showed with great distinctness the peculiar and characteristic spectrum which he ascribes to the presence of the new element jargonium, and noticed that the bands became much more pronounced after ignition and cooling.

Space will not allow us to append the analytical processes employed; but we may briefly state that the result of the examination when summed up indicates the composition of the jargon to be as follows:—

Silica	.. .. .	33.61	} 66.28
Zirconia α	.. .. .	46.12	
„ β (jargonium?)	.. .. .	7.64	
„ γ	.. .. .	12.64	
Sesquioxide of iron	.. .. .	.24	
		100.13	

The formula $\text{Zr O}_2, \text{Si O}_2$ ascribed to zircon requires:

Silicic acid	33.77
Zirconia	66.23
	100.00

with which the numbers found for jargon are closely approximative.

The results of this chemical examination must be considered as strengthening the evidence, physical and chemical, that the earth usually denominated zirconia is, in reality, a compound of two, if not more, closely allied oxides.

The details of an experiment, very important from a theoretical point of view, have been published by M. E. Drechsel; this is the reduction of carbonic acid to oxalic acid. Clean sodium is placed along with some sand in a clean flask, and a rapid stream of carbonic acid gas is passed into the flask, which, at the same time, should be heated to the temperature of boiling mercury; the metal assumes a purple colour, and after a few hours is converted into a dark pulverulent mass. After having cooled, the substances are withdrawn from the flask, and the mass is exhausted with water, the aqueous solution saturated with an excess of acetic acid and precipitated with chloride of calcium, whereby the salt, oxalate of lime, is obtained: 60 grms. of sodium yield, by this process, 6 grms. of pure oxalate of lime.

M. Boettger remarks that oxide of thallium inflames sulphuretted hydrogen when coming in contact with it; so do pure peroxide of manganese, peroxide of lead, and peroxide of silver obtained galvanically. With binoxide of barium, chlorate of lead, and chlorate of silver, the gas becomes vigorously inflamed; fulminate of silver also inflames the gas, and the salt explodes. Iodide of nitrogen explodes in contact with the gas, and gun-cotton is inflamed by it under certain conditions.

Dr. Matthiessen has succeeded in preparing, by the action of hydrochloric acid on morphia, a new base which is likely to be of considerable value from a physiological point of view.

Morphia is sealed up with a large excess of hydrochloric acid, and heated to 140° – 150° C. for two or three hours. The residue in the tube contains the hydrochlorate of a new base, differing considerably in its properties from morphia. It may be obtained in a state of purity by dissolving the contents of the tube in water, adding excess of bicarbonate of sodium, and extracting the precipitate with ether or chloroform, in both of which the new base is readily soluble, whilst morphia is almost insoluble in both menstrua. This new base is called apomorphia.

When the hydrochlorate of apomorphia in a moist state is exposed to the air for some time, or if the dry salt is heated, it

turns green, probably from oxidation, as the change of colour is accompanied by an increase of weight. The base itself, newly precipitated, is white, but it speedily turns green on exposure to air. The green mass is partly soluble in water, communicating to it a fine emerald colour; it dissolves in alcohol, yielding also a green tint, in ether giving a magnificent rose-purple, and in chloroform giving a fine violet tint.

The physiological effects of apomorphia are very different from those of morphia: a very small dose produces speedy vomiting and considerable depression, but this soon passes off, leaving no after-ill effects. Dr. Gee is now studying these effects, and has found that $\frac{1}{10}$ th of a grain of the hydrochlorate subcutaneously injected, or $\frac{1}{4}$ grain taken by the mouth, produces vomiting in from four to ten minutes. Mr. Prus allowed himself to be injected with $\frac{1}{10}$ th grain, which produced vomiting in less than ten minutes. From Dr. Gee's experiments on himself and others, he concludes that the hydrochlorate is a non-irritant emetic and powerful anti-stimulant. From these properties it appears probable that it may come into use in medicine.

M. Hager observes that, although elementary chemical analysis of caffeine and theine yields results which would conclusively prove the identity of these two substances, yet the author found that the physiological effect, after partaking of a dose of .25 grm. of both substances chemically pure, is by no means the same. The human organism is imbued with testing powers, compared with which chemical reagents are of little delicacy.

Dr. Hofmann has described a convenient method for the formation of ferric acid. An intimate mixture is made of one part of *ferrum limatum*, and two parts of nitrate of potassa; these are heated in a small glass flask over a strong gas flame; the mixture soon becomes quite incandescent, emits out of the mouth of the flask a firework of sparks, and leaves at last a mass partly fused into the glass of the flask, consisting of ferrate of potassium. After cooling, this mass is reduced to powder, and being exhausted with water, yields a deep-reddish violet-coloured nearly transparent solution.

Commercial chloroform is frequently adulterated with alcohol and ether, and it is sometimes of importance to ascertain whether these impurities are present in any given sample. In order to discover this, the chloroform should be first treated with fused chloride of calcium to eliminate any water; next some iodine must be added. If the chloroform is free from either alcohol or ether, the colour produced by the solution of the iodine is bright red; but when either alcohol or ether is present, the colour of the solution is brown. In order to distinguish between alcohol and ether, a

small piece of a crystal of fuchsine is added to the chloroform in question; when the slightest trace of alcohol is present, a deep-red solution will ensue. Perfectly pure chloroform yields, with fuchsine, a solution which is only slightly pinkish tinged.

In a long research on the subject of atmospheric ozone, M. Houzeau demonstrates that the air of the country is of a different character from that of towns; that the former is strongly disinfectant, has far greater bleaching power, and, especially after rainfall, affects bright and oxidizable metals far more than is the case in towns. In his paper the author calls attention to some facts readily observed—as, for instance, the rapid bleaching of all kinds of woven fabrics, be they made of linen, cotton, or woollen fibre; the rapid fading of very many dyed tissues; the far more active rusting of iron, steel, and even copper, in the country, as compared with large towns. Curiously enough the author does not mention the well-known fact of the effects of the air at sea, even at comparatively short distances from the shore, nor the peculiar effects produced by the mountain air at no greater height than from 2000 to 6000 feet above sea-level.

Oenoline is the name given by M. Morat to the colouring matter met with in genuine red wines obtained from grapes. It is obtainable by treating the wine by a very complicated process, and ultimately the colouring matter is precipitated as a red-coloured flocculent substance, insoluble in ether, very difficultly soluble in water, soluble in alcohol, and insoluble in benzol.

Professor Rochleder, of Prague, has found that when madder is treated with dilute mineral acids, it yields, besides alizarine and purpurine, a small quantity of a third tinctorial substance, which, in alkaline solution, has a great similarity to chrysophanic acid. This substance is soluble in alcohol and in acetic acid, and crystallizes from these solutions in orange-yellow coloured crystals; its aqueous solution, mixed with acetic acid and brought to the boiling-point, imparts to silk and wool immersed in it a beautiful and durable golden-yellow colour.

There is met with in commerce, under the name of Victoria yellow, or aniline orange, a reddish powder, which yields highly yellow-coloured solutions, and bears in general great likeness to the binitro-naphthol compounds. MM. Martius and Wichelhaus have instituted some researches on this material, and have found it to be a nearly pure binitro-cresol salt. The binitro-cresol they separated from it is readily soluble in alcohol, ether, chloroform, and boiling water. It may be obtained in crystalline shape. The dry substance fuses at about 110° C. The authors have tried in vain to obtain, by the experimental method, a clue to the mode of manufacture and

origin of this material. The solutions of binitro-cresol gradually become deep-red coloured on exposure to air.

M. Ponsard has applied Siemens's furnace to the manufacture of iron. He states that he has succeeded in producing 1 ton of cast iron, of excellent quality, with a consumption of only 1 ton of fuel. The author summarizes his results in the following manner:—1. A great saving of fuel can be made, and iron obtained from its ores without the use of the blast-furnace. 2. That, since the heat produced by flame is sufficient to effect all the chemical reactions and melt the metal, there may be used all kinds of fuel which produce gas—that is to say, all kinds of coal, no matter whatever their quality, wood, lignite, peat, hydrogen gas, and mineral oils. 3. It is possible to obtain, at will, a more or less carburetted metal, according to the quantity of carbonaceous matter which is mixed with the ore and placed in the crucibles to act as a chemical agent only. Specimens of iron, of very good quality, obtained by the process as carried on by the author, have been exhibited to the members of the French Academy.

The great solubility of protoxide of nitrogen in water, especially if its temperature is rather low, has induced M. S. Limnosin to try what the physiological effects of such a solution would be upon men and animals. The solution of the protoxide of nitrogen in cold water, obtained under ordinary pressure of the atmosphere, tastes decidedly saccharine, if by means of pressure water has been made to absorb a large bulk of this gas; as might be expected, this solution is readily decomposed by substances capable of taking up oxygen. The main point of importance in this paper is the anæsthetic action of the gas and solution alluded to.

M. Payen has taken the trouble to analyze a piece of old woodwork, once belonging to the well-known Chaillot pumps, in order to ascertain what state the cellulose was in after fully a century's exposure to wind and weather. By appropriate treatment he obtained pure cellulose, as might have been expected. This was evidently also expected by Field-Marshal Vaillant, who happened to be present when the *savant* deposited, at a meeting of the Agricultural Society, a piece of pure cellulose obtained from the wood of the old pump, since the Marshal asked Payen, jocosely, whether he had not some old wood from the ruins of Carthage to operate upon; and M. Robinet, improving upon the occasion, offered to send Payen a piece of the wood from Noah's Ark, to continue his researches.

Artificial ebony is the name given to a substance prepared on the large scale in the following manner: 60 parts of charcoal, obtained from sea-weeds, and previously treated with dilute sulphuric acid and dried, are ground to powder, and mixed with 10 parts of

liquid glue, 5 of gutta-percha, and $2\frac{1}{2}$ of caoutchouc, care having been taken to mix the two latter substances with coal-tar oil, and thus to render them gelatinous; next, 10 parts of coal-tar, 5 of pulverized sulphur, 2 of pulverized alum, and 5 of powdered resin are added, and the mixture heated to 300° F. After having cooled, a substance is obtained which, in every respect, is said to equal genuine ebony wood, but is far less expensive, and takes a finer polish.

M. H. Pajot has made a series of experiments on the large scale at the blast-furnaces of Baudonnay, département de l'Orne, and found that the fact announced many years ago by Messrs. Lyon Playfair and Bunsen, of the presence of cyanide of potassium in blast-furnaces, is a reality, and that the salt is formed there in such large quantities that it might easily become a useful and plentiful by-product of ironworks.

A French technical paper especially devoted to the art of paper-manufacture, states that any alterations or falsification of writings in ordinary ink may be rendered impossible by passing the paper upon which it is intended to write through a solution of gallic acid in pure distilled water. After the paper thus prepared has become thoroughly dry, it may be used as ordinary paper for writing; but any attempt made to alter, falsify, or change anything written thereon, will be left perfectly visible, and may thus be readily detected.

On the evening of the 22nd of May last, at 9.45 P.M. local time, there was heard at Vannes, the capital town of the department of Morbihan, a heavy report, like that due to the firing of large ordnance, while the sky was at the same time illuminated by a bluish white light, accompanied by sparks somewhat like those of fireworks. The next day M. Limur learned that, at Cléguerec, a meteoric stone had fallen, which had been broken into pieces by the peasantry, and fragments of which, weighing 22 and 16 kilos., had been secured by some parties who, knowing the value scientific men attach to these extra-terrestrial visitors, will shortly send them to Paris for investigation.

PROCEEDINGS OF THE CHEMICAL SOCIETY.

In continuance of our reports of this Society, we have to record that on June 3 the Society met to hear a lecture by the President (Dr. Williamson) "On the Atomic Theory." It is impossible for us to give a condensed report which will do justice to so important a subject.

The Chairman, Dr. Miller, proposed a vote of thanks to

Dr. Williamson, and said that it would be better to defer the discussion. He would, however, remark that those who opposed the atomic theory must explain how, according to the notion of the infinite divisibility of matter, they had combination in definite proportion at all. It seemed to him utterly impossible to explain combination in definite proportion by the theory of infinite divisibility.

On the 17th of June the Society met at the Royal Institution, Albemarle Street, on the occasion of the delivery, by the celebrated French chemist Dumas, of the Faraday Lecture.

The President, Dr. A. W. Williamson, F.R.S., first addressed the meeting in appropriate terms, introducing M. Dumas. He said that the Society was here assembled to inaugurate what would be inadequately described as a monument in honour of Faraday. The Faraday Lectureship had been founded by the Council of the Chemical Society in the hope that it would promote the advancement of human knowledge, and surely no higher tribute of respect could be paid to a great man than to do in his name what he would have loved best to see done. The greatest difficulty which is experienced, and the greatest defect which one observes, is this, that workers in one line of thought are frequently ignorant, or insufficiently cognizant of what others are doing, and the defect shows itself between those who are working in different countries more than between those who are working in the same country. Now, imagine that we could induce to come among us a man possessed of one of those master minds which forms a focus of light throughout science and amongst all those who are interested in science; suppose that he were to tell us the thoughts which are uppermost in his own mind, and—best of all—that he were to make us for a time think with him in the very words of his own language; imagine that such a highly-gifted man combined in his own person the genius of a discoverer, the breadth of intellect of a philosopher, and the lucid fluency of an orator. I am sure that you would agree with me, that his visit would inaugurate something which Faraday would truly have rejoiced to see. Imagine, I say, those things, accurately fix in your mind's eye the image of such a man—and Dumas is before you.

M. Dumas's lecture commenced with a brief *éloge* of his friend the late Professor Faraday. The lecturer then, with admirable eloquence, passed to the consideration, first, of what he termed "*la matière brute*," and of its forces; and secondly, of organic matter and the forces special to it. He traced the origin of some of the more important modern chemical doctrines, of the labours of the Greek philosophers, and identified the principle of the ancient classification into fire, air, earth, and water, with that of Lavoisier's chemical elements. He acknowledged his great admiration of the labours of Dalton and Prout, and in a most lucid manner pointed

out relations between the atomic weights of the now received elements which led him to infer the probability of many of them having a common basis.

The conclusion of this lecture was so eloquent, and at the same time so profoundly suggestive of new lines of thought, along which chemists have scarcely yet penetrated, that we cannot refrain from quoting it *in extenso* :—

“The chemist has never manufactured anything which, near or distant, was susceptible even of the appearance of life. Everything he has made in his laboratory belongs to ‘brut’ matter; as soon as he approaches life and organization he is disarmed.

“Is the intimate nature of matter known to us? No! Do we know the nature of the force which regulates the movement of the heavenly bodies, and that of atoms? No! Do we know the nature of the principle of life? No!

“Of what use then is science? What is the difference between the philosopher and the ignorant man?

“In such questions the ignorant would fain believe they know everything; the philosopher is aware that he knows nothing. The ignorant do not hesitate to deny everything; the philosopher has the right, the courage, to believe everything. He can point with his finger to the abyss which separates him from these great mysteries,—universal attraction, which controls ‘brut’ matter; life, which is the source of organization and of thought. He is conscious that knowledge of this kind is yet remote from him, that it advances far beyond him and above him.

“No! Life neither begins nor ends on the earth; and if we were not convinced that Faraday does not rest wholly under a cold stone, if we did not believe that his intelligence is present here among us and sympathizes with us, and that his pure spirit contemplates us, we should not have assembled on this spot, you to honour his memory, I to pay him once more a sincere tribute of affection, of admiration, and respect!”

6. ENGINEERING—CIVIL AND MECHANICAL.

THE past quarter has certainly been rather prolific of engineering enterprises, and can boast of the completion of two most important projects, in addition to the development of a third which will probably, ere long, rival Sir Rowland Hill's penny postage in its universality and general public value.

Government and the Telegraphs.—By an Act passed in the last Session of Parliament power was given to confirm certain agreements which had been entered into between the Post-office autho-

rities and the various telegraph companies and railways throughout the country. An Act of the past Session empowers the Postmaster-General to pay to the various companies the sum of 5,715,047*l.* for the purchase of their undertakings; a further sum of 700,000*l.*, it is estimated, will be required for the purchase of telegraphs belonging to railway companies whose lines are doing public telegraph business; and 300,000*l.* has, in addition, been set down as the probable amount that will be required for extensions. The present proposals of the Post-office authorities are to serve with means of telegraphic communication some 3376 places instead of 1882 as at present. Altogether a sum of 6,750,000*l.* is expected to be required for the purpose, and the gross annual revenue is set down at 673,838*l.* The net profits to Government have been estimated at from 44,000*l.* to 77,000*l.* per annum, according as to whether the money can be raised at 4 or 3½ per cent.

Pacific Railroad.—The completion of the Pacific Railroad has given a line of communication 3300 miles long, between New York and San Francisco, connecting the Atlantic with the Pacific Ocean, and crossing a mountain range higher than any other line in existence. On the 28th April last 10 miles and 58 feet of railroad were completed between daylight and sundown, a feat hitherto unparalleled in railway construction, and as such one well deserving of record in these columns.

French Atlantic Cable.—The successful completion of the laying of the French Atlantic cable is another engineering achievement of which the present age may fairly boast. The manufacture of the core for this cable was commenced on September 14, 1868, at the gutta-percha works, and the cable was finished in the first week of last June, at the sheathing works at East Greenwich. The route along which this cable is laid is well to the southward of existing cables; the point of departure from the French coast is between Brest and Cape Ushant, and the landing-place on the American coast is the small French island of St. Pierre. From thence a shallow-water cable is laid down the coast to Duxbury Cove, near Boston, Massachusetts. The greatest depth of water is 2200 fathoms in the deep-sea section. The quantity of cable manufactured for these sections is 3564 nautical miles, or about one-third longer than either of the existing Atlantic cables. The Great Eastern, with the main portion of the cable on board, reached Brest on the 21st June last, the French shore-end having been previously laid. A splice having been successfully made, the Great Eastern steamed off on her trans-Atlantic voyage early on the morning of the 22nd June, accompanied by a small fleet of minor vessels carrying other portions of the cable. On 15th July the laying of the cable was completed to St. Pierre, without the occurrence of any serious hitch or delay of any kind; and on the 15th of August last

the French Atlantic Telegraph Company opened their line for traffic. Thus the longest line of submarine telegraph in existence has been brought to a successful completion within eleven months of the commencement of its manufacture.

The Channel Passage.—In our last Chronicles reference was made to the various schemes recently put forward for effecting the better passage of the Channel between England and France. Since then the subject has attained increased importance, from the fact that publicity has recently been given to the report of a commission appointed by the French Emperor to examine into the project of a submarine railway between England and France, the result of whose deliberations was a recommendation to the effect that "The exploratory and preparatory works should be executed under the inspection of commissioners appointed by the two Governments (of England and France), to whose approbation the company should submit yearly in advance the plans and estimates to be executed in the current year, and who should control the expenses usefully made." From a further section of the report, however, it appears that "Three members of the commission are of opinion that the proposed undertaking appears to be incapable of producing sufficient remuneration for the capital employed; that, thus looking at it from a purely economical point of view and setting aside considerations which the Government are more competent to decide on than the commission in the present case, at this present moment there are no grounds for recommending the acceptance of the propositions of the committee." From the evidence taken by the committee, it appears that the chalky mass found at Cape Blanc Nez is reproduced with the same characteristics on the other side the Channel, between Folkestone and Dover. The lower part of the chalk-bed consists of grey and marly chalk, having a mean thickness of 55 to 65 yards, which crops up at Cape Blanc Nez and near Folkestone. "In this situation its composition is uninterrupted and free from fissures, and possessing, on account of the marly beds which are intercalated with it, a degree of elasticity which the engineers expect would be maintained." On the whole the commission express their opinion that driving a submarine tunnel in the lower part of this chalk is an undertaking which presents reasonable chances of success; but in the absence of further information, they decline to mention any sum as the probable amount which would be required for its completion.

A report on the best means of facilitating communication between England and France has since been drawn up by Captain Tyler, of the Board of Trade. This officer has an evident leaning towards the lesser expenses contemplated in Mr. Fowler's large ferry-boat scheme, rather than to the projects of Mr. Hawkshaw, M. de Gamond, and the late Mr. Chalmers, for effecting absolute

and direct communication with the Continent by means of a sub-aqueous tunnel. The substance of Captain Tyler's recommendations may be summed up in the following extract from his report:—
"Either by the construction of new harbours at Dover and Andreselles, at a cost (estimated by Mr. Fowler) of 2,000,000*l.* inclusive of steamers, or by certain improvements at Dover and Boulogne, at a cost of 600,000*l.* exclusive of new and improved steamers, the immediate object should be to provide an improved fixed service, irrespective of wind and tide, between London and Paris in eight hours." Thus this important matter rests for the present, but it remains to be seen what further action will be taken by the two Governments towards the solution of a project, the commercial and international advantages of which may be estimated as being scarcely second to those of the Suez Canal. The appointment of an International Commission for the purpose of discussing the several projects for effecting improved communication with the Continent, as recommended by Captain Tyler, will, however, probably prove the best means of bringing this important question to a satisfactory issue.

Utilization of Small Coal.—Although we are no believers in the probability of the speedy exhaustion of our coal-fields, we are nevertheless, upon other grounds, strongly in favour of all measures calculated to economize our present supplies, and to check the extravagance which now characterizes our use of that fuel. In addition to improved arrangements of furnaces whereby more perfect combustion is ensured in the coal ordinarily used, namely, that which is taken from the pits in blocks of some size, attention has recently been given, in more directions than one, to bringing into use the small coal, or slack, which had previously been counted as so much waste. Some reference to this subject will be found in another part of the present volume, in an article on "Coal Washing." Besides its conversion into coke, which is now very much the practice at all collieries, small coal is, to a certain extent, employed in the manufacture of Patent Fuel; and at the present time experiments are being carried out in this country by Mr. F. C. Danvers, for the Indian Government, with a view to ascertaining whether that manufacture could be successfully introduced into India, so as to utilize further than is at present done the coal products of that country. Methods of burning small coal, without subjecting it to any previous preparation, if equally applicable, must, however, prove the more economical process, and several furnaces have from time to time been devised for this purpose. It is almost needless here to state that the most perfect furnace would be that in which proper means exist for the regulation of the introduction of air in the best direction into the combustion chamber, so as to effect the most perfect combustion of the fuel,

whilst the fire-grate must be so arranged as to avoid the disadvantages usually attendant on the use of slack, such as the loss of a quantity of fuel by falling, unconsumed, through the bars, or the obstruction of a proper draught by cakeing into blocks over them. Fire-doors of this description are made by Messrs. Newton and Newton, at Liverpool, and appear to possess great advantages, not only in enabling slack to be burned where large coal would otherwise be necessary, but by a proper regulation of the air admitted to furnaces to which they are fitted, more perfect combustion is ensured, resulting, consequently, in the almost total prevention of smoke.

We cannot close this subject without a brief notice of Mr. Thomas Russell Crampton's process of burning fuel in the form of a powder. Many previous experiments have been made both in England and America to effect a similar object, but they have failed to achieve that amount of success which Mr. Crampton appears to have arrived at. Mr. Crampton's process, described in few words, consists of an arrangement by which a portion of finely-powdered coal is blown into a furnace, where at first a small fire has been lighted. This immediately bursts into flame, and by properly adjusting the proportions of air and coal-powder, a flame is then regularly kept up, giving out an intense heat, and leaving little or no residue in the shape of clinkers or ash. Want of space prevents further allusion to this subject now, but we shall return to it again upon some future occasion.

MEETINGS OF SCIENTIFIC SOCIETIES.

Institution of Civil Engineers.—The President's annual conversazione took place on Tuesday, the 25th May last, at which there were present an unprecedented number of visitors and members. The meetings of the Institution have now been suspended until the autumn.

Institution of Mechanical Engineers.—The annual meeting of this Society was held at Newcastle on 3rd August last, and following days, under the presidency of Sir William Armstrong, when the following papers were read:—"On the Hydraulic Swing Bridge over the Ouse," by the President; "Mechanical Ventilation of Mines," by Mr. William Cochrane, of Elswick; "Mechanical Firing of Steam Boilers," by Mr. John Daglish, of Seaham; "Hydraulic Machinery for Warehousing Grain," by Mr. Percy G. B. Westmacot, of Elswick; and on "The Navigation of Canals," by Mr. Max Eyth, of Leeds. The President, in his address, which was given before a crowded audience on the evening of the first day's meeting, after alluding to the present year being the cente-

nary of the steam-engine of Watt, briefly referred to the early history of its invention and progress. He then entered upon the subject of coal-mining; the construction and use of large ordnance; armour-plating; the future of the steam-navy, and gun-carriages.

Civil and Mechanical Engineers' Society.—Two meetings of this Society have been held since our last Chronicles were written, which took place on the 2nd and 9th June respectively. At the former meeting the Society was occupied in listening to, and subsequently discussing an able paper by Mr. Arthur C. Pain, C.E., "On the principal Building Stones used in the Metropolis." And on the latter occasion a very interesting paper was read by Mr. Frederick H. Roberts, C.E., on "Steam and other Power Hammers."

LITERATURE.

'*A Manual of Machinery and Millwork*,'* by William John Macquorn Rankine, C.E.; LL.D. Trin. Coll., Dublin; F.R.S.S. London and Edinburgh; F.R.S.A., &c. &c. This volume forms the last of the series of practical manuals to which it belongs. Those which have preceded it are probably well known to many of our readers. The professional position and world-wide reputation of the author are sufficient to stamp all his works with an authority which place them almost above the range of criticism. The work now under review is divided into three parts, treating respectively of the "Geometry of Machinery," the "Dynamics of Machinery," and the "Materials, Strength, and Construction of Machinery," each part being subdivided and the subject matter treated under various and well-arranged headings. Want of space prevents any more detailed account of the present work, but we may, in conclusion, state that, although dealing with the principles of machinery and millwork, it is of a character entirely distinct from that of Dr. Fairbairn's excellent work on Mills and Millwork, the latter treating more of the practical application of principles, whilst Professor Rankine's work deals with the principles themselves.

* London: Charles Griffin & Co.

7. GEOLOGY AND PALÆONTOLOGY.

(Including the Proceedings of the Geological Society and Notices of Recent Geological Works.)

MR. ROBERT HUNT has contributed a highly suggestive and interesting paper to the 'Bath and West of England Agricultural Journal' * on "The Economic Geology of Devonshire and Cornwall in 1868." In it the author points out that, although other districts may exhibit greater varieties in their geological formations, yet there are few in which the *rock-conditions* are so peculiarly adapted to the production of that high fertility which distinguishes Devonshire, or the varied and valuable metalliferous deposits of Cornwall. Mr. Hunt gives a brief sketch of the various deposits which characterize the two counties, and proceeds to show the intimate connection which exists between the rocks beneath and the fertility of the soil above. He thinks that the agriculturist might study with advantage the geologically-coloured map of a district, and learn from it which are the more and which the less productive tracts; but he points out that elevation above the sea, exposure to prevailing winds, drainage-lines, &c., must also be taken into account.

The author contrasts the soils lying on the Lias, the New Red Sandstone, the slaty series (Devonian and Carboniferous), and especially to those derived from the decomposition of eruptive rocks and granites, as yielding good crops of ordinary farm-produce, and favourable to the growth of grass and potatoes. He mentions the beneficial results witnessed by spreading "China-stone," a semi-decomposed talcose granite, in small pieces over a field of wheat, and suggests that we may yet add many new fertilizers to the list of artificial manures offered to the farmer. He affirms that the relations of geology to agriculture are not yet in a satisfactory condition; but that, in addition to the maps now issued, showing the boundaries of the rock-formations, we need maps of the surface, showing the variation and distribution of soils. He also adds the welcome intelligence that Government has organized measures for accomplishing this end.

Turning from agriculture, Mr. Hunt proceeds to describe the mineral resources of the district. Commencing with fuel, he states that 1368 tons of the Bovey Tracey lignite are annually used at the Bovey Potteries, besides the district consumption. These beds belong to the Miocene age, and are only a little older (geologically) than our peat-mosses and peat-bogs, which can also be cut and utilized as fuel. None of the four million tons of coal, drawn

* Vol. xvi.

annually from our Coal-measures proper, are obtained from this area.

From coal we pass to tin, copper, lead, iron, zinc-ore, nickel, wolfram, manganese, arsenic, &c., and then to building-stones, ornamental marbles, roofing-slates, flagstones, lime, whetstones, clays for pottery, &c., yielding a total value of 1,876,739*l.* for the two western counties.

The Depths of the Sea.—In a lecture lately delivered before the Royal Dublin Society, by Prof. Wyville Thomson, the lecturer gives us the results of dredging operations carried on by Dr. Carpenter and himself last year in deep water between the Faroe Islands and the Hebrides.

Two areas were explored—a “cold area,” where the bottom was of stones and coarse sand, and on which the thermometer registered a minimum temperature of 32° F., and where the fauna consisted of a meagre sprinkling of boreal and arctic forms—and a “warm area,” the “Gulf-stream area” (530 fathoms deep), with a minimum temperature of 47·5 F., where the floor was covered with fine grey slimy mud, technically called “ooze,” but which Prof. Wyville Thomson considers should be called “chalk-mud.” This area, which formerly yielded only the shells of a Rhizopod (*Globigerina*), now proved to be also rich in siliceous sponges, about forty of which were obtained on one occasion, a little south of the Faroes. Most of these sponges had long and venerable beards of flint-spicules, as fine as the finest floss-silk, spreading out into the chalk-mud in all directions. These beards brought up, entangled in them, small clams, starfishes, and minute crustaceans; and among the mud were scattered the shells of the beautiful and well-known Pteropods of the Gulf-stream.

There can be no doubt, adds Prof. Wyville Thomson, that Chalk is now being formed in the depths of the Atlantic; and not only Chalk, but THE CHALK—the Chalk of the Cretaceous Period. That, in fact, the physical and biological conditions of the greater part of the ocean have remained unaffected by the later geological changes embraced within the Tertiary and Quaternary Periods, which represent only minor oscillations, the deposits formed during those periods being all laid down in comparatively shallow water, as shown by the nature and richness of their faunæ.

It is gratifying to find that whilst the results arrived at from the more perfect appliances for modern deep-sea dredging have so materially modified the late Professor Edward Forbes's conclusions as to the depths in the ocean at which life could be sustained—yet they have also tended to confirm the doctrine which he long ago enunciated, that the persistence of the same fauna over an extended geological area did not prove it to be synchronous, but rather the reverse.

In the latter part of 1867, Mr. W. Hellier Bailly (Palæontologist to H. M. Geological Survey of Ireland) published Part I. of 'Figures and Descriptions of Characteristic British Fossils' (Van Voorst). We are glad to notice the publication of Part II. with Plates 11-20 (Lower and Upper Silurian). This publication is not intended in any way to interfere with 'Morris's Catalogue of British Fossils' (the third edition of which is very much needed by all palæontologists). Mr. Bailly's aim has rather been to assist geological students, and others who, from their limited knowledge of palæontology, require to have figures of the various fossils placed before them, as well as their names and references, in order to enable them to identify their specimens. Those who have the good fortune to possess a scientific reference library, or who can use that of some public institution, can hardly understand the assistance which such a work as this affords to others who, from their isolated position, are denied these advantages.

We hope Mr. Bailly may soon be able to complete the publication of his 'Figures and Descriptions of British Fossils,' that we may enjoy the use of it, *as a whole*, before many years have passed away.

The 'Geological Magazine' contains various articles of interest. The following chiefly deserve notice:—

1. A full report (with illustrations) of Mr. W. Carruthers's lecture, at the Royal Institution, on "The Cryptogamic Forests of the Coal Period." Mr. Carruthers points out that the Flora of the Coal Period all belonged to the Vascular Cryptogams, and represent—(a) the Ferns; (b) the Horse-tails, *Equisetaceæ*; (c) the Club-mosses (*Lycopodiaceæ*). After describing the modern representatives of these three types, the author proceeds to point out that in the Coal Period, (a) Ferns were most abundant, mostly, however, humble herbaceous forms, very few attaining the size of modern tree-ferns; their leaf-forms being nearly all comparable with living species. (b) The *Equisetaceæ* were well represented in the Coal Period, but instead of being dwarf marsh-plants, they attained often a very large size. He described the stems, the various forms of foliage and fructification belonging to this group, and pointed out their affinity to the modern Horse-tail (*Equisetum*). (c) He next considered the fruit and stem of *Lepidodendron*, contrasting those giant trees with the modern Club-mosses, and showed that in that point most relied on by Botanists—the spores—there was a close agreement. He spoke of *Sigillaria*, another arborescent form, also a member of the same family as *Lepidodendron*. These are the plants to which we are indebted for our stores of mineral fuel. They grew in extensive level plains, their fleshy roots penetrating the soft mud which formed the surface-soil, or the spongy layer of vegetable matter which covered it. The

moist atmosphere (not at all likely to have been charged with more carbonic acid gas than that of our own day) would encourage the growth of cellular parasites and epiphytes, &c., probably representing races much higher in organization than the cryptogamic trees on which they flourished. The examination of the Flora of the Coal Period reveals to us an assemblage of plants agreeing in all essentials with some of the humble members of our present Flora, but attaining at so early a period in the history of the world, a development, not only in size, but in organization, greatly in advance of their modern allies.

2. The fourth part of Mr. Davidson's "Notes on Continental Geology and Palæontology, including a Sketch of the Geology of Nice."

3. "Notes and Figures of the Teeth of *Ctenodus* from the Coal-measures," by Mr. T. P. Barkas.

4. "On the Genus *Æchmodus*, from the Lias of Lyme Regis," by Professor Morris, F.G.S. (with a plate). In this paper Professor Morris considers the genera *Dapedius*, *Æchmodus*, &c., and discusses the characters upon which they are founded. These Liassic fishes, with their tessellated surface of highly enamelled black rhomboidal scales, form most striking objects among the fossils of this singularly rich deposit, and, from the perfect state in which they are frequently found, are sure to attract special attention.

5. Dr. Linnarsson's paper "On Fossils from the Eophyton Sandstone of Sweden" is reproduced, together with the original plates representing these singular bodies, believed by Dr. Torell and some naturalists of eminence to be plant-remains, but of the certainty of such determination much doubt still exists; they have by others been considered worm-tracks and Trilobite-markings, &c. Whatever their origin, they seem to be due to organic bodies, which is, after all, the main point of interest.

6. Professor Owen contributes a note on the occurrence of the Elk with the Reindeer, &c., at Walthamstow, in Essex.

7. Sir Philip Egerton supplies a list of the Typical Fishes in his collection at Oulton Park, which he states are open to inspection by all who take an interest in palæontology.

8. Mr. H. C. Sorby contributes a note "On the Excavation of Valleys in Derbyshire."

9. Mr. H. B. Medlicott "On Faults in Strata;" and

10. Mr. G. H. Kinahan "On the Growth of Soil, Formation of Ravines," &c., &c.

PROCEEDINGS OF THE GEOLOGICAL SOCIETY OF LONDON.

As there are twenty-nine papers published in the August number of the Quarterly Journal of this Society, it is impossible to do more than to briefly notice one or two of the most important ones:

1. Professor Henri Coquand compares the Cretaceous strata of England and the North of France with those of the West and South of France and the North of Africa. In this paper the author points out that although a comparison may be made between the Cretaceous beds of Paris and in the North of France with those of England, without any great discrepancies being discovered, immediately one examines the Cretaceous beds of Provence, one finds—1st, thick beds with *Radiolites*; 2nd, 300 mètres of Sandstones (Grès d'Uchaux); 3rd, 150 mètres of Limestone with *Hippurites*, which are wanting both in the Parisian and the English Chalk series. He pleads, and we think with justice, that, as each district possesses its peculiar and local formation, it is there that one should seek for the type, and that if these beds had occurred in England we should certainly have made an horizon for them, and given them a place and a name; why then should they not take a place in the series, and be recognized by foreign geologists?

2. Mr. W. Carruthers, "On the Structure and Affinities of *Sigillaria* and allied Genera," indicated the characters of the medullary rays of dicotyledonous stems, and stated, that they have a vascular horizontal system connected with the axial organs, in which respect they agree with acrogens. The woody columns of *Stigmara* and *Sigillaria* are destitute of medullary rays, the structures previously described as such being the vascular bundles running to the rootlets and leaves. Hence the author concluded that *Sigillaria* is a true cryptogam.

3. Professor T. H. Huxley describes a new Labyrinthodont Amphibian reptile from the Black-bed coal of Bradford, Yorkshire, which the author considers was nearly allied to the genus *Pholidogaster*, and for which he proposed the name of *Pholiderpeton*. It exhibits portions of both jaws, with close-set, nearly equal teeth, nearly circular in section, and slightly recurved at the apex. The ventral armour consists of oval plates, traversed obliquely by a convex ridge dividing them into two unequal parts; these plates overlapped each other so as to expose only the surfaces of their oblique ridges.

4. "On the Upper Jaw of *Megalosaurus*," by the same author. The information concerning the skull of this reptile was very defective, only a portion of the lower jaw being known heretofore. The beautiful upper jaw, with the teeth, now figured and described, from the Stonesfield Slate, adds greatly to our knowledge of this very interesting and gigantic Dinosaurian.

It shows the left side of the jaw, measuring 18 inches in length and $4\frac{1}{2}$ inches in depth anteriorly. One tooth, exposed in its whole length by the breaking away of the bone, measures 6.4 inches, of which the crown forms only 2.6 inches. An animal with almost identical teeth, the *Teratosaurus Suevicus*, of Von Meyer, occurs in the Lower Keuper of Stuttgart, thus giving to this type of Dinosaurian a range from the Trias to the Wealden.

Among the Geological papers, the most important is that by the Rev. J. M. Joass "On the Sutherland Gold-fields," and by Mr. J. J. Murphy "On the Nature and Cause of Glacial Climate."

We regret that want of space precludes our noticing the numerous other papers contained in this number.

8. METEOROLOGY.

Meteorology in France.—Our last Chronicle was barely in type, when the statements contained in it relating to the organization of meteorological operations in France were shown to be incorrect. We learn now that the Government has communicated to the Société Météorologique its intention of instituting a complete system of meteorological observations, in a connection more or less intimate with the Society. A commission has been appointed, with Prof. Charles Sainte-Claire Deville as its President, to superintend the work. A central observatory has been established at Montsouris, near Paris, with which it is hoped that other institutions will soon be affiliated, and the issue of a daily bulletin of the observations made at Montsouris has been set on foot since the beginning of July. It may therefore be expected that ere long a complete system of meteorological observations will be in operation, and we cannot but express our satisfaction at the evidence which these facts afford that the authorities in Paris fully recognize and identify themselves with the work so long and so well done by the Meteorological Society of France. As regards the issue of the Bulletin International, no modification of the service at the Observatoire Impérial will be made in consequence of the change.

The Aurora.—The remarkable auroras noticed on April 15 and on May 13, of which Mr. Barber was so kind as to furnish a notice for our last number, have attracted very considerable attention over the whole of Europe, and have formed the theme of several interesting communications to scientific societies. Among the most important of these have been the notices submitted by MM. Silberman and C. Sainte-Claire Deville to the French Academy, and contained in the Comptes Rendus. These gentlemen, the former especially, have

paid particular attention to auroral phenomena of late years, and the views entertained by them receive abundant confirmation from the facts observed on the dates in question. The connection between the aurora and magnetic storms is well known and recognized, but the relation between its appearance and the phenomena of our weather is not as yet nearly so universally admitted. The opponents of the idea of the existence of any relation, naturally and very justly urge the frequency of auroras in high latitudes, without any concomitant disturbance of atmospherical equilibrium. We must, however, remember that magnetic intensity is in general much greater in high latitudes than in our own, so that in these countries it is only at times of disturbance of the magnetic conditions of the atmosphere that we are to look for an exhibition of auroral appearances. The fact that auroras do occur nearly simultaneously with periods of stormy weather is too well established to be doubted; the point to be determined is whether there is or is not a connection between the two phenomena. Some connection is distinctly assumed as a fact by the authors of the papers we are now discussing. They show that the aurora manifests itself on the appearance of a centre of barometrical depression (a "bourrasque"), and that it belongs to the earlier period of the disturbance, when pressure is decreasing rapidly and temperature increasing,—in fact, to the period which is usually characterized by the manifestation of electrical phenomena such as thunderstorms. M. Silberman attributes the aurora to the gradual discharge towards the higher regions of the atmosphere, of the electricity contained in a thundercloud. This discharge only takes place when streaks of cirri emanate from the upper surface of the cloud, so that in fact it is induced by the congelation of aqueous vapour into the minute ice prisms of which the cirrus is known to be composed. The chief points in support of his theory, brought forward by M. Silberman, are the fact that cirri are almost invariably noticed as being present in the space above the dark segment during the exhibition of an auroral discharge; it is often remarked that the phenomenon entirely disappeared when the sky became completely overcast with a stratum of cloud; that during an auroral period, in the daytime, when their luminosity cannot be observed, it is frequently noticed that cirri occupy the position of the rays of the aurora;* and that frequently during an aurora a fall of small

* Very recently a remarkable confirmation of M. Silberman's statements has been witnessed by the writer of this Chronicle. On August 25 he was travelling from Thurso to Wick, and at 5 P.M., while the sun was shining brightly, he observed a dark bank of clouds along the northern horizon, exactly resembling the dark segment of an aurora. From this cloud long rays of cirrus directed towards the zenith emanated. Although at this period of the evening no auroral light was visible, it was remarked by some persons who observed the phenomenon that this was the commencement of an aurora. During the night the sky, which had been very clear for some days previously, became entirely overcast; but before this

crystals of ice, as distinguished from hail, has been observed. M. Silberman has himself noticed that at night thunderclouds, when there is no moon, give off occasional faint coruscations from their upper surfaces, and that when this latter appearance becomes of greater permanency, the ordinary electric discharge, producing a thunderstorm, is entirely suppressed.

This idea of a relation between the aurora and the cirrus-cloud goes to establish a relation between the aurora proper and the appearance of luminous clouds, which are occasionally noticed. It is also interesting in this connection to refer to the remarkable observations made many years ago by Sir E. Sabine, at Loch Scavaig, in Skye, where he remained for a short time at anchor in a yacht. One of the mountains close to the loch was constantly covered with a cap of cloud, and at night discharges of a true auroral character were seen to emanate from this cloud. It was distinctly proved that these did not belong to an aurora at a distance, of which the lower portion was obscured by the mountain. Another fact, in some way corroborative of M. Silberman's views, is that some of our most experienced arctic observers state that the aurora is never noticed unless there be open water in the vicinity of the observer, and consequently a considerable degree of humidity in the air.

The auroras to which the papers in question especially refer are very remarkable, owing to their very great extension; that of April 15 being noticed from the Azores to Central Germany, and that of May 13 from the British Isles to Russia, where it was well observed. In a communication to the Academy of Sciences of St. Petersburg, Prof. Wild gives an extract of a letter from Von Struve, of the observatory at Pulkowa, who remarked that the phenomenon, though remarkably brilliant, was chiefly noticed in the east, and that the dark segment was entirely absent. This latter particular was especially adverted to by M. Silberman in Paris, who remarked that its place was taken by a number of small clouds in various parts of the sky, forming separate auroral foci.

The April number of the 'Proceedings of the British Meteorological Society' is mainly composed of two papers on the influence of the moon on rainfall, which lead to diametrically opposite conclusions. Mr. Dines states, as a result of the discussion of forty years' observations, that no influence is traceable; while Mr. Glaisher has submitted fifty-four years' observations to calculation, and has arrived at the conclusion that the amount of rain which falls increases to a maximum about the tenth day of the moon's age,

occurred, the light of a faint aurora was perceived. Next day was very cloudy, and in places in Scotland rain fell. On the 27th the sky cleared again, another aurora appeared at nightfall; and on the 28th a very sudden change of weather occurred, the temperature falling very rapidly, while a strong N.W. wind set in, attaining in some places the force of a gale.

while the average amount of rain "per fall" has its maximum at the end of the lunation. The differences are, however, not great, and it seems scarcely necessary to have printed twenty-three pages of tables on such a subject.

Underground Temperatures.—The April number of the 'Journal of the Scottish Meteorological Society' contains a paper by Mr. Buchan, being the first notice of the observations of underground temperature carried on at certain stations in Scotland. The Marquis of Tweeddale, President of the Society, had most liberally placed 50*l*. at the disposal of the Council, to be expended in investigating the question. The thermometers were placed at depths of 3, 12, and 22 inches, under grass, at all the stations but one, where they were placed under the bare soil, so as to reproduce the conditions of a freshly-sown field. As might be expected, the last-named station exhibited a much higher temperature at the depth of 3 inches than those where the soil was covered by vegetation. The results are of some interest. In drained ground the surface temperature of the soil rose above the temperature of the air to the extent of $2^{\circ}\cdot4$ on the mean, while in badly-drained ground it fell slightly below the air temperature. Light soils also exhibited an excess of temperature as compared with that of the air, while heavy soils were characterized by a defect. These results are naturally to be expected, as a dry light soil is a much worse conductor of heat than wet heavy ground.

There is one observation which merits special notice; on a cold day, with a north-east wind, cloudy but dry, it was found that the thermometer at the depth of 3 inches rose above that in the air $3^{\circ}\cdot7$ at Sandwick Manse, where it was under grass, and 5° at Thirlestane Castle, where the soil was uncovered, while the temperatures at 12 and 22 inches respectively scarcely varied during the day. This shows us that during the cold east winds of spring seed in the ground may be enjoying a temperature much higher than our sensations of air temperature would lead us to expect, and it also accounts for the greater severity of the east winds on the east coast than on the west, which they can only reach after having travelled over a large extent of heated soil. Mr. Buchan is disposed to attribute the elevation of temperature to the radiation of heat from the clouds.

Meteorology of Iceland.—The same number contains a notice of the meteorology of Iceland, based on the observations of Mr. O. Thorlacius, carried on for twenty-three years. The results are interesting, when we compare them with the corresponding figures for Scotch stations noticed in our last number; however, they exhibit some points of difference, the mean pressure showing only 2 maxima and 2 minima instead of 3. The chief feature of the barometrical tables is a great depression noticed in the month of January, and

amounting to 0·3 inch below the mean of the year, and to 0·5 below the extreme monthly mean of that of May. At Glasgow the difference between the means of January and May amounts to only 0·17 inch. Pressure in Iceland is most unsteady in February, and most steady in July.

We may here notice the discussion of the scientific results of the German North Polar Expedition of last year, which has been published by the Meteorological Office of Hamburg (the Nord-deutsche See-warte). It appears from the meteorological observations that the large and unexpected accumulations of ice met with by the 'Germania,' which had the effect of preventing her reaching the coast of Greenland, were in great measure connected with the abnormally low mean temperature prevailing in high latitudes during last summer. The mean daily temperature observed on board the ship was $3^{\circ} \cdot 5$ F. lower than that which was due to her geographical position. These facts afford a strong corroboration of the views long maintained by Prof. Dove, viz. that there is a constant compensation between the non-periodic variations in meteorological means. A warm season in any region is an indication that in an adjacent district the weather is unnaturally cold. Our readers will not forget the great warmth of last summer (1868), and yet during the whole of the period the temperature north of the parallel of 70° was unusually low. As regards the winds observed, the general direction of their change was from N.E. through N. to N.W., being thus in contravention of the law of gyration. Storms were far more frequent from the N. and N.E. than from any other quarter. The extraordinary prevalence of calms and of fog and mist is also very noticeable.

Deep-Sea Temperatures.—The paper, which is a report of a lecture delivered by Herr von Freeden, at Hamburg, contains a long discussion on the currents, &c., noticed during the voyage, and also some notes as to deep-sea temperatures and their indications as to submarine currents. As to the observations themselves, none go to a depth greater than 170 fathoms, where a temperature of 33° was recorded. The position assumed by the lecturer in interpreting the observations is rather at variance with the ideas generally entertained. Herr von Freeden states that by recent observations in the open sea it has been established beyond a doubt that salt water possesses a maximum density at $39^{\circ} \cdot 5$ F. In No. 22 of this Chronicle we entered on this question at some length, but new light has since been thrown on it.

On the one hand, Prof. Mühry of Göttingen has published a notice in the Journal of the Austrian Meteorological Society, in which he states that having tried the experiment, he finds that salt and fresh water have the same point of maximum density, and that, accordingly, all deep soundings ought to show this temperature.

On the other hand, investigations carried on here in London have led to the idea that the deep-sea temperatures hitherto recorded, many of which were far below 39° , have been as a general rule much too high. No account had been taken of the alteration in shape of the thermometer-bulb produced by the compression to which it was subjected in deep soundings.

On this subject Prof. W. A. Miller submitted to the Royal Society, in June, a notice of a thermometer calculated to register correct temperatures, independently of pressure. The principle on which this new thermometer is constructed is one which had been tried by Admiral FitzRoy some years ago, and it is this. The entire thermometer is enclosed in an outer glass coating, the interval between the two surfaces being nearly completely filled with a liquid. Compression of such an instrument only causes the liquid to fill a larger proportion of the intermediate space, and the bulb of the internal thermometer is entirely unaffected.

In Admiral FitzRoy's thermometers this liquid was mercury; in Prof. Miller's it is spirit. We learn from the paper submitted to the Society that the new instruments have been subjected to very severe hydraulic pressure in a special apparatus, constructed by Mr. Casella, their maker, and have performed very well.

The 'Porcupine' has been furnished with these instruments, and we may hope that the savans who take part in the present dredging expedition in the Atlantic will bring home some thoroughly trustworthy information as to the physical condition of the sea beneath the surface.

Report of the Meteorological Office.—The Report of the Meteorological Committee for the year 1868 has just appeared. The value of the information contained in its seventy-two pages must not be judged of by its price, which is only 5*d*. It consists of two parts, with copious appendices. From the summary of Part I. we learn that the department of marine meteorology has made steady progress during the year in the discussion of observations relating to the equatorial portion of the Atlantic Ocean, and in the collection of new observations. We have already noticed the charts of sea-surface temperature which have appeared, and we learn that in addition to these charts materials have been supplied to the Admiralty for the compilation of pilot charts.

The system of telegraphic weather intelligence, established by the Committee, is in active operation, and storm warnings are sent to 101 stations on our own shores and to the adjacent coasts of the Continent. The work of the office in this department is carried on in cordial co-operation with that conducted in foreign countries.

As regards the land meteorology of the British Islands the seven observatories are in active work, and the most earnest attention of the Committee has been directed to the utilization of the

records furnished by their self-recording instruments in the study of weather, and their publication in a graphical form, which shall be acceptable to the scientific public. It is satisfactory to learn that some progress is being made in placing weather study on a secure scientific basis.

Part II. of the Report is an account of the means adopted by the Meteorological Committee, in conjunction with the Kew Committee, to ensure accuracy in the numerical results obtained from the records of the observatories. According to the plan adopted, each observatory supplies to Kew the photograms furnished by the instruments, together with hourly numerical values of the readings obtained by measurement. These are examined at Kew; and when certified as correct, are sent to the central office in London for discussion, &c.

The experience of the first few months showed that a more searching examination at Kew than had at first been contemplated was necessary, in order to prevent errors creeping into so large a mass of figures. The mode in which this examination is carried out is given at full length.

On the fly-leaf of the Report we see notices of other publications; an account of which, together with other meteorological literature, must be reserved for our next number.

9. MINERALOGY.

NOTHING tends more to impede the progress of a science than the hasty enunciation of laws based upon too narrow an induction. As our means of observation become extended, it is easy to detect the fallacy of many of our premature generalizations; but it is extremely difficult to eradicate the influence which they may have exerted on the formation of our scientific ideas. Our attention has recently been directed by Dr. Laspeyres to the crudeness of many of those general propositions which, for several years past, have been accepted, with more or less reservation, as natural laws regulating the association of those minerals which enter into the composition of rocks. His remarks will be found in an excellent paper "On the Association of Magnetic and Titaniferous Iron-ores in Eruptive Rocks, and on the so-called Laws of Petrography."* It is commonly laid down, as a general proposition, that the two minerals here coupled together never occur associated as components of a rock—that, indeed, the presence of the one inva-

* 'Ueber das Zusammenvorkommen von Magneteisen und Titaneisen in Eruptivgesteinen, und über die sogenannten petrographischen Gesetze.' Leonhard und Bronn's 'Jahrbuch für Mineralogie,' u.s.w., 1869, p. 513.

riably betokens the absence of the other. Our author has, however, proved the co-existence of these species in the disintegrated product of certain volcanic rocks of the Palatinate, and also in an undecomposed rock, formerly termed gabbro, but which he now proposes to distinguish under the name of *Palatinite*. He is then led to a discussion of the ordinary laws of association among rock-forming minerals; and although he does not say very much that is original on this subject, it is nevertheless useful to review such a collection of facts as those which he has here brought together for the purpose of disproving most of the commonly-accepted conclusions. Thus he exposes the fallacy of the famous "law of the feldspars"—a law which, as most geologists know, teaches that the alkali-bearing feldspars—orthoclase, oligoclase, and albite—are never associated with the lime-feldspars—labradorite and anorthite. One argument against this law might be found in the recent views of Tschermak on the constitution of the feldspar-group, by which the so-called species, oligoclase and labradorite, are regarded as nothing more than isomorphous mixtures of the two extreme types—anorthite and albite. Moreover, as a matter of fact, Laspeyres has himself pointed out the existence of a lime-and-soda feldspar, closely related to the labradorite type, in certain basaltic lavas of the Lake of Laach, where orthoclase had previously been found. In like manner, sanidine—a variety of orthoclase—occurs with anorthite in the andesite of Nagy-Bánya.

This example must suffice to show the kind of evidence with which our author sweeps away many a long-cherished notion; but it may please those who cling tenaciously to the old articles of faith to know that, in spite of the progress of science, a few of the petrographical laws still hold their ground; such, for instance, as the absence of white potash-mica from the younger eruptive rocks.

So much interest naturally attaches to anything bearing on the history of those strange visitants from extra-terrestrial regions, which occasionally reach our earth in the form of *meteorites*, that no apology is needed for calling attention to an excellent *résumé* of our knowledge on this subject, lately published by M. Stanislas-Meunier.* Most of our readers know that meteorites are divisible into two great groups—meteoric *stones* and meteoric *irons*. The members of the former class are composed of a stony base, consisting of a complex mixture of various magnesian silicates, only partially attacked by acids; those silicates which have the composition of olivine being decomposed, whilst others, resembling hornblende and augite, are left intact. Throughout this base of siliceous minerals, numerous grains are usually disseminated in greater or less number, some of which are metallic, and consist,

* "Recherches sur la composition et la Structure des Météorites : " 'Annales de Chimie et de Physique,' série iv., tome xvii. p. 5.

for the most part, of nickeliferous iron, chromite, and troilite. The author gives his analyses of three meteorites, one of which fell at Murcia, in Spain, on 24th Dec. 1858, and was exhibited in the Paris Exhibition; the second fell at Tadjera, in the district of Sétif, Algiers, on the 9th June, 1867, and is remarkable for the absence of that crust, or varnish, which usually invests such stones; whilst the third is a meteorite that fell on the 7th Sept. 1868, at Sanguis-Saint-Etienne, in the département of the Basses-Pyrénées. To economize space, we place the analyses side by side, and give only the mineralogical—not the chemical—composition.

	Murcia.	Sétif.	Basses-Pyrénées.
Silicates attacked by acids } (olivine) }	38·69	54·64	66·91
Ditto not attacked (augite) ..	24·64	28·80	23·57
Nickeliferous iron	14·99	8·32	8·05
Chromite	0·92	0·20	traces.
Troilite	20·52	8·04	3·04
	<u>99·76</u>	<u>100·00</u>	<u>101·57</u>

In the class of metallic meteorites the general mass is not homogeneous, but consists of a number of alloys of iron and nickel, each having a definite composition. Of these the most important are taenite, kamacite, plessite, and octibbehite. With these alloys are associated certain carbides of iron, chiefly chalypite and campbellite, a sulphide of iron called troilite, a phosphide of iron and nickel termed schreibersite, graphite or free carbon, and chrome iron-ore. Certain stony grains are also occasionally present, and frequently the surfaces are coated with a crust of oxidized matter. Add to this the occluded gases sometimes met with—such as the hydrogen found by Graham, and the nitrogen by Boussingault—and we have what in the present state of our knowledge is a complete catalogue of the constituents of meteoric irons.

At about 6 o'clock in the evening of the 5th May, 1869, a meteoric stone fell at Krähenberg, in the Bavarian Palatinate.* It presented the form of a flattened spheroid, and weighed $31\frac{1}{2}$ lbs.; its surface was covered with a black rind, and exhibited numerous furrows. An account of this aërolite was read at the recent meeting of the British Association.

According to Dr. Schncke, we can only hope to obtain an insight into the nature of those recondite forces that produce crystalline form, by determining with quantitative accuracy the relative degrees of resistance which a crystal opposes in different directions to the action of external mechanical forces. With this view the learned Doctor has instituted a very elaborate series of experiments on the manner in which the cohesion of rock-salt varies

* Poggendorff's 'Annalen,' 5th May, 1869.

in several crystallographic directions.* Small rectangular prisms were cut from the salt of Stassfurt, having their axes normal to the faces of various crystalline forms. The tenacity of the prism was then determined by attaching a scale-pan, and loading it until fracture occurred. It was thus found that the prism always broke along a plane parallel to the face of a cube, but that the breaking strain varied considerably, according to the direction in which the prism had been cut.

In working the Jacobsglück lode at Andreasberg in the Hartz, a peculiar and extremely rich *argentiferous sand* has lately been found.† The lode contains many drusy cavities irregular in shape and variable in form, the larger ones being usually empty, whilst the smaller ones are filled with sand. By examination under the microscope and before the blow-pipe, this sand is found to contain native silver in minute octohedral crystals, and in scalenohedral forms probably pseudomorphous after calcite. It is notable that silver does not occur crystallized elsewhere in the Andreasberg district; while, on the other hand, red silver ore, which is a common mineral in the veins, is absent from the sand. The pulverulent material contains, however, chloride of silver in very small cubes; and this, strangely enough, never occurs crystallized in the mines, and is, indeed, a rare mineral in the district. Calcite, quartz, and a yellow amorphous mineral not yet determined, complete the list of constituents of this true "silver sand."

Among the many rich gold-bearing veins of the Maldon Mining district in Victoria, few have excited more interest than the "Nuggetty Reef." Mr. Salter, the manager of the Alliance Company's mines, has detected in this lode a peculiar metallic mineral, which in the hands of Mr. Ulrich turns out to be a new species.‡ *Maldonite*—as we are to call it—occurs as a silver-white, slightly pinkish mineral, with a bright metallic lustre rapidly tarnishing. It is softer than pure gold, very sectile, and exhibits apparently a cubic cleavage. Its chemical examination showed it to be an alloy of bismuth with gold.

From the copper mines of Namaqualand Mr. Gregory has obtained a mineral, which Professor Church has described under the name of *Namaqualite*.§ It occurs in thin layers made up of short silky fibres, exhibiting a pale-blue colour, and consisting, apparently, of a "cupric aluminic hydrate," thus formulated:— $\text{Al}_2 \text{H}_6 \text{O}_6. 3 \text{Cu H}_2 \text{O}. 4 \text{aq.}$

Jakobsite is Damour's name for a new species related to the spinel group, found in the mines of Jakobsberg, in Wernland,

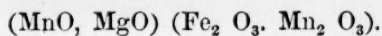
* Poggendorff's 'Annalen,' 1869. No. 6, p. 177.

† Leonhard u. Bronn's 'Jahrbuch,' 1869, p. 445.

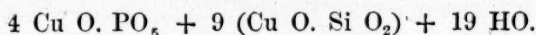
‡ 'Notes on the Nuggetty Reef,' Maldon, Victoria. By G. H. F. Ulrich, F.G.S.

§ 'Chemical News,' July 30, 1869, p. 53.

Sweden.* It is a black, lustrous, magnetic mineral, crystallizing in octohedra, having a specific gravity of 4.7, and a composition expressed by the formula:—



From Nischne Tagilsk, in the Urals, a sky-blue compact mineral has been examined by M. Hermann, and described as a new species under the name of *Cyanochalcite*.† It is composed of phosphate and silicate of copper, thus represented:—



A new ore of the rare metal tellurium has lately been found in the Sierra de Tapalpa, in Mexico.‡ Professor del Castillo transmitted a specimen to Rammelsberg, whose analysis leads to the formula: $\text{Ag}_2 \text{S Bi}_2 \text{Te}_2$. Such a substance might, of course, be a mixture of minerals, but Rammelsberg himself believes it to be a definite compound, and therefore a new species.

The same active chemist has also been at work on the composition of several native silicates, including chabazite, stilbite, desmine, mesotype, scolecite, and serpentine.

Some crystals of smoky quartz of gigantic proportions have recently been found in a difficultly accessible part of the Canton Uri, in Switzerland, and the details of the discovery have been published by Dr. Fellenberg.§

In optical mineralogy it will be sufficient to call attention to Dr. Kossmann's elaborate paper on the peculiar lustre and dichroism of hypersthene.||

10. MINING AND METALLURGY.

MINING.

THE Mines Inspection Bill, which may be regarded as an example of that uncertainty which ever attends all attempts at legislation when individual interests are forced into opposition to the ends in view, has, at the last hour, been postponed for another year. Twelve Inspectors are left, as before, to look after the safe condition of upwards of 3000 collieries; and the coal miners remain still at the mercy of that superintendence which, sometimes good but often imperfect, has prevailed during the past years which have witnessed

* 'Comptes Rendus,' July 19, 1869, p. 168.

† 'Journal für praktische Chemie,' 1869, p. 65.

‡ 'Zeitschr. d. deutsch. geolog. Gesell.,' xxi., p. 81.

§ 'Berner Mittheilungen,' 1869, p. 135.

|| Leonhard's 'Jahrbuch,' 1869, p. 532.

annually the sacrifice of about a thousand human lives in the production of upwards of 100 millions of tons of coal.

As the last act of this drama for the year, Lord Elcho called the special attention of the House of Commons to a memorial signed on behalf of 30,000 miners, "praying for a special inquiry into the recent accidents in coal-mines, that have resulted in great loss of life." To this Mr. Secretary Bruce's reply is worthy of preservation:—"It was natural that the workmen, whose lives were constantly threatened, should look to the Government for protection from dangers, and, within proper limits, the Government ought to grant them that protection; but, at the same time, the workmen ought themselves to co-operate. Their occupation was attended by peculiar dangers, from which no Government could wholly exempt them. By the co-operation of the men those dangers might be much lessened; but, in the absence of such co-operation, he altogether despaired of seeing a reduction in the number of lives lost in consequence of accidents in mines. The Government ought to have in every locality a certain number of competent men to listen to every warning and rumour of danger, but it was no *part of their duty to examine personally into the state of every colliery!*" It is part of their duty to inspect every infant school to ascertain if the teacher is competent, and to grant money for its support, but the lives of colliers, often placed at the mercy of ignorant men, are of no moment. So says the Home Secretary!

A conference of delegates from various associations of coal-miners was held in Manchester on Monday the 23rd August. At this meeting the delegates advocated, with their usual indiscretion, the eight hours system, and, as it appears to us, indulged, most unfortunately, in a series of misrepresentations regarding the Government Inspectors and the Colliery owners. Desiring above all things that the rights of labour should be acknowledged, we cannot but feel that the endeavour now so constantly made by the delegates to sow the seeds of evil between the employer and the employed is only postponing for an indefinite period the end desired. The miners' grievances are many; but it must never be forgotten that the miners have duties as well as grievances, and that the removal of the one depends greatly upon the faithful performance of the other. At the meeting to which we have referred, it was urged that all the blame regarding accidents rested with the masters, who were, whenever an accident happened, to be convicted of manslaughter, if not of murder. Is it possible that the speakers could have been ignorant of the positive wilfulness of the men themselves, who, in defiance of all the rules, act as if they believed they had some especial immunity from danger? Let us hope that in time some better system of training will place the coal-miner beyond the injurious influences of men who so sadly misrepresent the truth.

The discovery of a new coal-field in India has been exciting considerable attention. The following remarks from one of the Calcutta journals will be read with interest:—

"There has been a great 'find' of coal in the Central Provinces, and I beg the attention of the Great Indian Peninsula Railway to the fact. The district of Chanda lies due south of Nagpore, between that and the river Wurdah, which forms the northern boundary of Hyderabad. For some years Captain Lucie Smith, the Deputy-Commissioner, has been boring for coal; and Mr. Mark Fryar, the practical geologist sent out lately to report on our coal resources, has more than confirmed his estimate of the value of his discoveries. Mr. Morris, the officiating Chief Commissioner, has written with great caution on the subject, until Messrs. Mather and Platt's steam-borer, which has been sent for, arrives. But ordinary borings and the opinions of Mr. Medlicott—Geological Surveyor under Dr. Oldham, who is Director-General of the Indian Geological Survey—Mr. Bonner, C.E., and Mr. Fryar, reveal a vast and thick and uniform deposit of coal, which has led the last to urge Government to begin mining operations at once, and to make a branch railway to the main Great Indian Peninsula line. The sandstones of the Chanda basin are the same as the well-known coal-bearing sandstones of Raneegeunge, to which, indeed, Mr. Fryar compares the deposits in value and extent. He is confident that there are at least two square miles of coal 14 feet thick at a depth of 300 feet, and in easy working position, on the Chanda side of the Wurdah, while there is a certainty of more than the same area on the other side. This practical Government geologist declares that the coal can be laid down, by branch railway, at Nagpore at 1*l*. per ton, giving a profit of 10*s*., while a ton of English coal costs 1*l*. 16*s*. at Bombay, and double that at Nagpore. If we so far discredit the Chanda coal as to say a ton of it is equal to only half a ton of English coal, it will still have 16*s*. in its favour at Nagpore. All India at present turns out 600,000 tons of coal a-year—not more than the produce of one good colliery in England; and the two square miles of Chanda coal would give the same supply for thirty years. Labour is abundant; the mines would prove a boon to a poor population. This is not all. The finest, if not the largest, cotton mart in India lies between Chanda and the main line of railway. That is Hingunghat, the cotton of which is so good that its seed is being introduced wherever the Sea Island and Egyptian varieties do not suit the inland climate. The Chanda coal-field is to the south of Hingunghat, and to the north of the finest cotton districts of Hyderabad. Cross the Wurdah to the south and you come to Edulabad, the cotton of which is so good that an English merchant has just laid out 10,000*l*. there, intending to send the produce down the river Godavery, of which the Wurdah is the main

affluent, to Coconada. A branch line for the cotton alone was long ago projected to Hingunghat. Now there is the coal. If even half of Mr. Fryar's expectations are realized, the least known part of India will be opened up, and the feudatory provinces of the Nizam, who will be a minor for the next fourteen years, will be enriched, while they are made to contribute their wealth of cotton and coal to the general good."

Mr. Mark Fryar has recently published a letter "On Coal-Mining in India," addressed to the "proprietors and managers of coal-mines in India," which cannot but produce a beneficial result in directing attention to improved methods of working the coal-mines.

In connection with this subject of coal-mining, Mr. Henry Bessemer, who is well known for his process of manufacturing steel, has—in devising a process for the production of a most intense heat for metallurgical processes—been led to suggest a modified form of that arrangement for lighting mines.* By combustion under pressure, Mr. Bessemer obtains the most intense heat, and the most vivid light, "a light that never fails, that never goes out, that never requires trimming, and, above all, a light that effectually prevents the mixture of air and gas which pervades all coal-mines from entering the flame and becoming ignited. Now these are precisely the conditions obtained by combustion under pressure, which offers to the miner a source of the most brilliant light wholly inaccessible to the inflammable air of the mine. As a simple illustration of the fact, let us suppose a small iron box, a little larger than a policeman's lantern, having a thick plate glass or a bull's-eye on one side of it; in the lower part is a common gas-burner, supplied by a pipe from a gasometer above ground; the supply of air to support combustion is arranged in a similar manner, and supplied under pressure from above ground; a small aperture is made in the top of the lantern for the escape of the products of combustion. Now, if air and gas are supplied to this light under a pressure of, say 1 lb. per square inch, the light would be brilliant, and the escape from the orifice at this pressure (or even far less) would prevent the possibility of any external gases entering and becoming ignited. In this way every gallery in a mine may be lighted like a workshop, to the great comfort and cheerfulness of those whose whole lives are spent in the cheerless-gloom of these dangerous workings."

The mode of advancing the light as the work progresses, and its direction by the use of reflectors, and other necessary details of the system, are simple enough, and need not be here entered into.

In Cornish mining a most decided improvement is evident, consequent upon the increased and remunerative price of tin. The

* See Metallurgical Chronicles.

value of several of the mines near Camborne and Redruth, at the present time, will be seen by the following statement of the monthly labour cost:—

Dolcouth	£2600	paid in August for Wages.
Pendarves United	1800	" "
West Seton	1400	" "
Wheal Seton	1100	" "
Tin Croft	1050	" "
Cook's Kitchen	1000	" "

In round numbers, 15,000*l.* a-month are now paid in wages by twenty-one mines in the Camborne district only.

The mineral wealth of Portugal appears to be developing itself in a somewhat remarkable manner. In 1853 there were but two mines in the kingdom, there are now

23 Coal mines	66 Lead and Silver mines
45 Iron "	85 Manganese "
98 Copper "	6 Gold "
29 Tin "	6 Antimony "

There are now altogether, in full operation, 220 mines.

The mining industry of Queensland is rapidly acquiring increased importance. In 1867 the value of the gold exported was 189,248*l.*; in 1868 it reached 593,616*l.* The value of the exports of copper and copper-ore have increased during the same period from 66,038*l.* in 1867, to 72,136*l.* in 1868.

Copper in Belgium.—In the neighbourhood of Vielsalm, in the province of Liège, some drainage works were in progress, when at no great depth beneath the surface a piece of native copper weighing about 2 kilos. was found. It was partly hollow, and exhibited a crystalline structure. A further search was made, and some veins of malachite were discovered.

Mr. Ball, of the Geological Survey of India, has communicated to the Asiatic Society some interesting notices "On the Ancient Copper Mines of Singhbhum." As a contribution to the history of mining, this paper is of considerable value. Those mines were probably worked about the same time as those of the Sinaian range, and probably served with them to supply the copper to form the bronzes which were so largely used when the great Eastern monarchies were in their glory. Mr. Bauerman has lately described, in the 'Quarterly Journal of the Geological Society,' the copper mines of Arabia Petrea.

The following remarks from the address of Sir Wm. Armstrong at the Newcastle Meeting of the Institution of Mechanical Engineers have, at the present time, a peculiar interest:—"England, with her innumerable steam-engines and manufactories, is more dependent upon coal for the maintenance of her prosperity than any other nation; and the question of the duration of her coal-fields, now, very properly, occupies the attention of a Royal Commission. The investigations of that commission are not yet completed, but, so far

as they have gone, the results are re-assuring. I concur in the probable accuracy of the announcement lately made by two of my fellow commissioners, that the total quantity of coal in this island will prove to be practically inexhaustible; but until the complicated details of quantities collected by the commission have been put together, and expressed in totals, it is difficult to judge with certainty or accuracy on the subject. Although the duration of our coal may, geologically speaking, be practically unlimited, we have still to consider the important question, How long will England be supplied with coal as good and as cheap as at present? We have unquestionably made greater inroads into our best and most accessible coal-beds than other nations have done into theirs; and if foreign coal should grow better and cheaper, and ours dearer and worse, the balance may turn against us as a manufacturing country long before our coal is exhausted in quantity. It is clear that our stock of good coal is very large, but most of it lies at great depths; and one of the most important questions the Royal Commission has to investigate is the depth at which coal can be worked with commercial advantage. The chief obstacle to reaching extreme depth is the increase of temperature which is met as we descend. I am justified, by ascertained facts, in saying that this rate of increase will, as a rule, prove to be not less than 1° Fahrenheit for every 20 yards in depth, and there is reason to expect that it will be even more rapid at greater depths than have yet been attained. The constant temperature of the earth, in this climate, at a depth of 50 feet, is 50° ; and the rate of increase, as we descend, is to be calculated from this starting-point. Adopting these figures, you will find that the temperature of the earth will be equal to blood-heat at a depth of about 980 yards, and at a further depth of 500 yards, mineral substances will be too hot for the naked skin to touch with impunity. It is extremely difficult to form an opinion as to the maximum temperature in which human labour is practicable in the damp atmosphere of a mine, and it is almost equally difficult to determine how much the temperature of the air, in the distant part of an extremely deep mine, can be reduced below that of the strata with which it is brought in contact. It is certain, however, that the limit of practicable depth will chiefly depend upon the mechanical means which can be provided for relieving the miners of the severest part of their labour; for maintaining a supply of sufficiently cool air at the working faces of the coal; and for superseding the use of horses, which suffer even more than men from highly-heated air. For the relief of labour we must look to coal-cutting machines; for improvement of ventilation to exhausting fans; and for the superseding of horses, to hauling engines driven by transmitted power. The employment of coal-cutting machines, working by compressed air, conveyed into the mine by

pipes, is already an accomplished fact; and when the difficulties and objections which usually adhere for a considerable time to new mechanical arrangements are removed from these machines, they will probably attain extensive application."

METALLURGY.

Mr. Henry Bessemer has recently patented a means of producing heat, which is of a very remarkable character. The principle involved will be understood from the following remarks by the inventor:—"I am at the present time busily engaged in investigating the action of combustion under pressure in furnaces where the flame is bottled up (so to speak) like steam in a steam-boiler, by which means heat is intensified in the ratio of the pressure employed, so that the most refractory substances known to man may be fused or dissipated in vapour with the same quickness and facility with which our most fusible substances are melted. In one modification of these furnaces the workmen operate in a large iron room, where the pressure of the atmosphere is greater than it would be at a depth of ten miles below the surface of the earth, and where the temperature, under ordinary circumstances, would be such that no attendant of a Turkish bath could endure it for a single hour. Yet these men and the furnace they tend may, by a simple arrangement of apparatus, be supplied with thousands of cubic feet of air per minute, as cool, or if necessary much cooler, than the surrounding atmosphere."

The following new process for obtaining iron from its ores has been brought before the Academy of Sciences by M. Ponsard. The author of this paper has applied Siemens's furnace to the manufacture of iron; he states that he has succeeded in producing one ton of cast iron, of excellent quality, with a consumption of only one ton of fuel. The author summarizes his results in the following manner:—

(1) A great saving of fuel can be made, and iron obtained from its ores, without the use of blast furnace; (2) that, since the heat produced by flame is sufficient to effect all the chemical reactions and melt the metal, there may be used all kinds of fuel which produce gas—that is to say, all kinds of coal, no matter whatever their quality, wood, lignite, peat, hydrogen gas, and mineral oils; (3) it is possible to obtain, at will, a more or less carburetted metal, according to the quantity of carbonaceous matter which is mixed with the ore, and placed in the crucibles to act as chemical agent only. Specimens of iron, of very good quality, obtained by the process as carried on by the author, were exhibited to the members of the Academy at this meeting.

11. PHYSICS.

LIGHT.—A diaphanometer to determine the transparency of different kinds of glass has been devised by M. Jicinsky. Without the engravings, it is impossible to make this instrument understood. The author has proved that the diaphanicity of divers kinds of glass is not dependent so much on its chemical composition, as on certain physical properties due to the heat applied in making it.

Physicists and others engaged in optical studies will feel interested in hearing that there has been a discovery of large crystals of quartz in a difficultly accessible portion of the Swiss Alps; one of these weighs 267 lbs., is 69 centimètres in height, and has a circumference of 122 centimètres.

The employment of the spectroscope to distinguish a feeble light present with a stronger light, has been suggested by M. Seguin. The author describes a series of experiments with electric light, and observations thereon with Duboscq's vertical spectroscope. The conclusion arrived at is that the spectroscope eminently serves the purpose of detecting a feeble light present along with a much stronger one, the former of which would be invisible to the naked eye, or by means of other optical instruments.

The zirconia light is attracting great attention on the Continent. The chief desideratum in oxyhydrogen illumination of this kind is the cheap production of oxygen; and the process of M. Tessie du Mothay, according to the Paris correspondent of the 'British Journal of Photography,' appears to be all that can be desired so far as cheapness and efficacy are concerned. It consists in heating in iron retorts, divided in two by a horizontal grating, a quantity of manganate of soda. This is raised to a dull red heat, and a current of superheated steam is made to pass over the mass. Oxygen is given off in abundance and passes along with the current of steam into a refrigerator, where the steam is condensed into water, and the oxygen is afterwards collected in a gasometer. The next operation is to re-oxygenize the exhausted manganate. This is accomplished by passing heated *air*, not steam, over it, when the manganate absorbs the oxygen, and becomes as ready as ever for yielding it again to the vapour of water. Thus the two operations can go on for an indefinite time, the air being the source of supply of oxygen. One advantage claimed by the advocates of the zirconia cylinders, besides their durability, is that a mixture of *equal* parts of oxygen and carburetted hydrogen can be used instead of a mixture in which oxygen is in excess, as is usual. There are large oxygen gas works for carrying out this method now erected in New York. The essential portions of the process are carried on by the aid of brick furnaces, of which only one was in operation at the

time of our informant's visit, several others being, however, rapidly fitted for use. Each furnace has its fire-box so arranged as not only to heat the retort which holds the manganate of soda, but also one or more chambers through which an air-blast passes to the retort. The retort furthermore communicates, by a pipe furnished with stop-cocks, with a suitable steam boiler. About 600 pounds of manganate of soda are placed in the retort, heated to the requisite degree in the furnace; superheated steam from the boiler is then admitted for about ten minutes. Two equivalents of the manganate of soda and two of water react upon each other, and the operation proceeds as described above.

A method of coating glass, porcelain, or earthenware, with a thin film of lustrous metallic platinum, has been published by Prof. Böttger. Dry chloride of platinum, freed from excess of acid, is mixed in a small porcelain mortar, with essential oil of rosemary, until the original brown-red colour of the salt has entirely disappeared, and has been converted into a black-pitch-like looking mass. When the pitch-like mass has been obtained, the oil is entirely removed, and the pasty mass is mixed with at least five times its weight of lavender oil, and mixed therewith to a homogeneous fluid; this, after having been quietly standing for half-an-hour, is applied with a hair brush on the glass or porcelain objects to which it is desired to give a coating of lustrous platinum, and after the very thinly and evenly laid on film is dry, the objects are either placed in a red-hot muffle, or heated in the flame of a glass-blower's lamp, care being taken not to exceed a red heat.

According to M. Grimm, chloride of copper completely removes even from coloured woven cotton tissues, stains occasioned by nitrate of silver; the tissue is to be afterwards washed with a solution of hyposulphite of soda, and next thoroughly washed with water. From white cotton and linen tissues, nitrate of silver stains are more readily and effectively removed by applying dilute solutions of permanganate of potassa and hydrochloric acid, followed by washing with hyposulphite of soda solution, and rinsing in plenty of fresh water. By these means the use of the highly poisonous cyanide of potassium is rendered unnecessary.

HEAT.—In the course of an introductory lecture on the occasion of the opening of the new laboratories at Berlin, Dr. Hofmann, F.R.S., illustrated some new experiments with flame, which he had devised for the purpose of showing its structure. Take a piece of canvas and put it on to the top of the glass chimney of an argand gas-burner, taking care to envelop the glass chimney previously with a very thin piece of copper foil, while the access of air at the bottom of the burner should be as much as possible prevented. On turning

the gas on, it escapes readily through the small openings in the canvas, and the gas may be ignited above. The canvas, however, soon takes fire and burns off, but leaves a very complete circular disc, which remains white and unconsumed in the centre of the flame. If it is desired to demonstrate more completely the nature of the flame, it is done by placing on the middle of the canvas disc some gunpowder, and on it the heads of some lucifer matches. After having again turned on the gas, and left it to escape for a few moments, it may be kindled again, and will burn quietly; and even though, as in the first experiment, the excess of canvas again burns off, neither the gunpowder nor matches will catch fire until just at the moment the gas is gently turned off.

M. W. Stein states that the vapour of perfectly pure disulphide of carbon is not decomposed when passed through a red-hot porcelain tube; but on repeating the experiment and increasing the heat by the application of a strong coke and charcoal fire, the inner space of the tube having been filled with broken porcelain, it was found to be lined with a deposit of carbon, owing to the decomposition of the sulphide, while sulphur was collected in a receiver.

While engaged with experiments on the intrinsic composition and constitution of various pieces of silver money, made at the Royal Netherlands Mint at Utrecht, Dr. A. von Riemsdyk carried on some experiments on the fusibility and volatility of metals. The author found that there does not exist any relation at all between the fusibility and volatility of metals, which may be arranged in the following manner, beginning from the most fusible and most readily volatile:—

	Fusibility.		Volatility.
Tin	228°·5 C.	.. ..	Cadmium.
Bismuth	268°·3 "	.. ..	Zinc.
Cadmium	320°·0 "	.. ..	Bismuth.
Lead	326°·0 "	.. ..	Lead.
Zinc	420°·0 "	.. ..	Tin.

Silver melts at 1040° C., pure gold at 1240° C., while the author found that chemically-pure copper requires a temperature of 1330° C. to become liquid. Neither pure silver nor pure copper loses anything at all by volatilization when kept for a considerable time at temperatures higher than the melting-points of both these metals, and in a feeble current of pure hydrogen to prevent their oxidation. The author has made some of these experiments on a very large scale, having at his disposal several hundred kilos. of these metals in pure and alloyed state.

ELECTRICITY.—It may be of some interest to our readers to know the theory which has been formed by the Rev. Father Secchi, S.J., on electricity. He writes, in a letter to M. F. Mazco, at Turin,

"I believe that the true theory of electricity will result from the principle that electricity is not a motion (*mouvement*), but a change of the quantitative and dynamic equilibrium of the ether which constitutes the atoms of the substances, and that the propagation of such a change is brought about by the moving of the ether from one atom to another; this motion shakes, disturbs the ether of the atoms, and thus produces heat."

An electrical phosphoroscope has been described by M. Laborde; its essential parts are a Ruhmkorff induction apparatus, the spark of which throws light on the phosphorescent object, and of a sliding frame, one of the ends of which hides the object during the brief moment it is illuminated by the electric spark. This sliding frame is 40 centimètres in length, by 10 centimètres in breadth; it is fixed at its centre on an axis, which may be made to move rapidly by means of a pedal. The arrangement of this apparatus is such as to render it serviceable for studying the phosphorescence excited by a blow, as well as by friction. The phenomena of phosphorescence of substances which, like nitrate of uranium, are only of very short duration, can be observed by means of this instrument equally well as the long-continued and strong phosphorescence induced by friction in pieces of porcelain or glass.

MM. Mure and Clamond have made a thermo-electric battery with galena. It is composed of sixty elements, made up of small bars of galena, 40 mm. in length by 8 mm. thick, and bars of thin sheet iron, 55 mm. in length by 8 mm. in width, and 0.6 mm. in thickness. These materials have been arranged so as to form a hollow cylinder, which, when it is intended to be used, is to be heated by a peculiarly constructed gas-burner. The specimen of this battery exhibited at a meeting of the French Academy had an electro-motive force of $1\frac{1}{2}$ Bunsen element. M. Becquerel read a lengthy paper on the subject of this battery, the result of which is that thermo-electric batteries constructed either of metallic alloys, or, as in this case, of a metallic sulphide and a metal, are not economical in use, and are too liable to changes brought on by the effects of the heat.

M. J. Meunier proposes to make use of the well-known experiment of Leichtenberg's electric figures to separate from each other the divers mineralogical constituents of some kinds of rock. We briefly remind our readers that the experiment alluded to consists in charging with electricity a cake of resin or sealing-wax, by means of a previously-charged Leyden jar; it is thus possible to charge certain portions of the cake with positive, others with negative, electricity. In order to exhibit this to sight it is usual to blow, by means of a small pair of bellows, on to the cake of resin, a mixture of very finely-powdered red-lead and sulphur; the friction on

leaving the nozzle causes the powders to become electrified, and the sulphur being negatively electric is attracted by the curved figures positively electric on the cake, while the red-lead follows the opposite course. M. Meunier has tried thus to separate sulphur-bearing trachite into its mineral constituents, and succeeded perfectly in getting the sulphide and feldspar from each other: he states that he has succeeded equally well with rocks made up of two different silicates.

12. ZOOLOGY—ANIMAL PHYSIOLOGY AND MORPHOLOGY.

PHYSIOLOGY.

The Temperature of the Human Body.—Mr. Alfred H. Garrod, of St. John's College, Cambridge, has made (and communicated to the Royal Society) a series of observations on a human "subject, aged 22, male, thin," whom we take to be himself, by means of very delicate thermometers and the sphygmograph, which he considers show that the minor fluctuations in the temperature of the human body, not including those arising from the movements of muscles, mainly result from alterations in the amount of blood exposed at its surface to the influence of external absorbing and conducting media. It has long been known that cold contracts and heat dilates the small arteries of the skin, respectively raising and lowering the arterial tension, and thus modifying the amount of blood in the cutaneous capillaries. But modifications in the supply of blood to the skin must alter the amount of heat diffused by the body to surrounding substances; and so we should expect that by increasing the arterial tension, thus lessening the cutaneous circulation, the blood would become hotter from there being less facility for the diffusion of its heat; and that by lowering the tension, thus increasing the cutaneous circulation, the blood would become colder, throughout the body, from increased facility for conduction and radiation. Thus the temperature and tension rise together on stripping off the clothes in a cold air—the temperature and tension fall by covering even a part of the body when stripped; simply heating the feet lowers the tension and the temperature of the body together. Mr. Garrod gives his observations very carefully, in numerous neatly-constructed tables, and appears to have well established his point. He remarks that the fall in the temperature of the body at night observed by Dr. Ogle, and by Drs. Ringer and Stewart, which is lowest at from 12 to 1 A.M., and rises after that time, is due to the fact that Englishmen go to bed

at about that hour and give up heat to the bed-clothes. Another explanation he offers has a practical importance for every reader. On a cold day the effect of sitting with one side of the body in the direct rays of a fire is to cause the other side to feel much colder than if there were no fire at all, because the fire lowers the tension all over the body, and supplies heat to the full cutaneous vessels of one side, while the other side being equally supplied with blood in the skin, does not *receive* heat, but has to *distribute* it rapidly to the cold clothes, &c. It should be mentioned that Mr. Garrod takes the temperature beneath the tongue, and that the variations recorded are all between 97° and 100° Fahr.—the variation of a tenth of a degree being readily recognized. Some interesting results of a similar nature might be obtained as to the cause of still smaller fluctuations by means of the thermo-electric scale.

The Cause of the Rouleaux of Blood Corpuscles.—Dr. Norris, of Birmingham, has recently repeated to the Royal Society the explanation of the phenomenon of the aggregation of the blood corpuscles which he put out in a former paper in 1862, and has exhibited his very ingenious and conclusive experiments. Dr. Norris constructed discs of cork of the shape of blood corpuscles, and found that when thrown into water they aggregated in the same *rouleaux* as do blood corpuscles. But he found that this result could not be maintained if the discs were perfectly submerged: hence there was a considerable difference between the case of the discs and of the corpuscles, which, of course, *are* submerged. At length Dr. Norris found that if he wetted the discs of cork or gelatine with which he experimented, and then placed them in a liquid which would not mix with the water, that the *rouleaux* were formed quite satisfactorily, even when the discs were submerged. The formation of *rouleaux* then depends on cohesive attraction—but on the cohesive attraction of *two* interacting bodies—in all Dr. Norris's experiments, and in the blood there are two dissimilar or antagonistic liquids; and upon the presence of these two the phenomena depend. The air acts the part of one of these in the case of *floating* discs. All that is required in the case of the corpuscles is a difference of this kind, between their liquid contents, as Dr. Norris prefers to say, or their viscous substance, as others may term it, and the plasma in which they are submerged. The difference need not be so great by any means as the difference between the liquids used in Dr. Norris's experiments (water and paraffin), since the corpuscles are so excessively minute.

The Movement of the Chest in Respiration.—Dr. Burdon Sanderson has constructed an ingenious instrument for measuring the frequency and intensity of the respiratory pulse, as it may be termed. Other physiologists have tried in various ways to con-

trive an instrument which should do this, but Dr. Saunderson has certainly improved upon all previous attempts. A large square pair of calipers made of steel forms the part of the instrument which grasps the chest, and which can be moved or adjusted to any particular size. The movements of the chest are made to press against a spring placed inside the arm of the calipers, and by the movement of the spring an india-rubber sack containing air is compressed. By a well-known and most ingenious device the compression of the air in the first sack is communicated through an india-rubber tube to a second larger sack placed at a convenient distance, and there the motion is transferred to a delicately-balanced lever, which being furnished with a brush and ink at its long extremity, writes off the movement on a regularly rotating cylinder. The advantage of this instrument is that it gives the whole movement of the chest in one line—the wall of one side of the thoracic cavity acting as a fixed surface in consequence of the calipers being applied to opposite sides. An important feature is, that so delicate is the spring and elastic sack apparatus, that the instrument acts as a cardiograph as well as a recorder of respiratory movement. The consequence is that the tracings from the revolving cylinder present two sets of curves: a large series, belonging to the movement of the thoracic walls; and a smaller set, due to the heart's impulse. Thus by this instrument one is enabled most clearly and satisfactorily to observe the relations of these two sets of movements and their interaction. Dr. Saunderson finds that this instrument confirms the observations which he formerly made with less satisfactory apparatus.

The Movement of the Wings of Insects in Flight.—M. Marey, perhaps the most original physiologist which France has produced in our time, has applied himself to the study of the movements of the wings of insects during flight. By gilding the tips of the wings of a hymenopterous insect, he was able to render it sufficiently brilliant to permit the eye to follow its movement, and he perceived that the tip of the wing described a figure of eight in its upward and downward movement. By applying a piece of sooted glass to the wing, he was able to get this movement marked off on a piece of glass. Now, to describe such a curvature combined with the flapping movement, supposing the wing to be a rigid body, would, M. Marey demonstrates, require a most complex arrangement of muscles, especially to produce such a movement with the great rapidity with which it occurs in the insect's wing. But the fact is that this "feathering" action of the wing is due merely to the up and down movement of the wing, coupled with its peculiar form and elasticity. M. Marey has made a model with wings, having one side rigid and the other tense but elastic, and he finds that on imparting a simple movement to these wings at their point

of attachment, exactly the same figure of eight is described as in the case of the real insect, and a propelling force is obtained sufficient to make the model move rapidly on a pivot.

MORPHOLOGY.

The Structure of the Organs of Taste in Man.—The existence of a peculiar terminal apparatus in each organ of special sense is now become an indubitable fact. This terminal apparatus has been studied with care for the organs of touch, of smell, of hearing, and, above all, of sight; but we were up to the present time in complete ignorance of the mode of termination of the gustatory nerve-fibres in the tongue. It is therefore very gratifying to find that, independently, two anatomists, Dr. Schwalbe and Dr. Christian Lovén, have studied this matter, and arrived at closely concordant results. The gustatory nerve-fibres by common consent have their terminations in the so-called *papillæ vallatæ*, and these are variously disposed in different mammifers. Their structure is complex, enclosing as a rule acinate glands, whilst the epithelium covering them is much thinner than that on the rest of the tongue. It is on the walls of the mote surrounding the papilla that it is thinnest. The gustatory organs discovered by Drs. Lovén and Schwalbe may be called gustatory bulbs. They occur only in the wall of the papilla limiting its circumscribed fossa. Each bulb, enclosed in an epithelial stratum, rests by an attenuated extremity directly on the mucous layer properly so called. Its form is that of a thick spindle, and the epithelium of the surface of the wall of the papilla is punctured by openings, each of which corresponds to the point of a gustatory bulb, so that by means of these apertures the gustatory bulbs are placed in direct communication with any fluids which may accumulate in the mote of the circumvallate papilla. The structure of the gustatory bulbs themselves is somewhat complex, but they contain elongated *bâton*-like cells, such as have been found in other special-sense organs. The nerve-fibres of the gustatory nerve lose their double contour before becoming united with these terminal organs, and the union is simply, as in other organs, between the naked axial cylinder and the elongate gustatory cells which make up the gustatory bulbs. Although in many cases these bulbs are restricted to the *papillæ vallatæ*, yet Dr. Lovén remarks that in some animals (man, sheep, and others) he has found them in some of the fungiform *papillæ*.

Professor Claparède's Writings.—The industry and skill of the Professor of Comparative Anatomy at Geneva are calculated to excite the highest admiration. It is only within the year that he has published a magnificent volume 'On the Annelids of the Bay

of Naples,' and he now appears again, first with an essay—written in German this time (he writes equally well in that language or in French)—entitled 'Studies on Acarids,' illustrated with eleven coloured folding plates; and secondly, with a joint paper in association with Professor Elias Mecznirow 'On the Development of Chætopodous Annelids,' illustrated with six coloured plates; besides these, he has in the press an extensive memoir 'On the Anatomy of the Earthworm.' Nothing could more clearly show the importance to the naturalist of possessing skill with the pencil than these beautiful labours of Professor Claparède. He is able rapidly to note down his observations by this means, and the very same faculty which enables a man to draw what he sees, makes him, at the same time, more apt at disentangling the intricacies of a structure, and more rapid and certain in his observation altogether. The 'Studies on Acarids' is perhaps the more important of the two works we have mentioned, since the development of several species is accurately and carefully detailed and figured; whilst the anatomy of several others is given, and some remarks headed "Für Darwin" are appended, pointing out certain arguments in favour of natural selection and descent which may be gathered from this group, as Fritz Müller has so well gathered from the crustacea.

A Living Cystidean.—The Cystidea are a very peculiar group of Echinoderms whose remains are abundant in the carboniferous and other Palæozoic rocks, and they have always been supposed to have become extinct before Mesozoic times. The sensations, therefore, evoked by the announcement of a living Cystidean may be well described as unusual. Yet Professor Lovén calmly describes in a paper only just published, an Echinoderm which he received from Cape York, and which appears to justify his assertion that it is a living Cystidean. In some features it agrees with the living crinoid *Comatula*, but in the fact that the canal between the ambulacral organs is covered in by calcareous plates, it agrees with the Cystidea alone. Further details and figures of this form are anxiously expected. Professor Lovén terms it *Hyponome*. It is worth mentioning, in connection with this, that at the depth of more than a thousand fathoms, Professor Wyville Thomson has, during the last month, dredged an Echinoderm, which he says must be regarded as the type of a totally new division of that group. For an account of his exceedingly interesting letter to Rev. Alfred Norman, read to Section D of the British Association, we must refer the reader to our Report.

Fresh-water Radiolarians.—The beautiful group, some forms of which are known to us as *Polycystina* in Barbadoes earth, which have been so wonderfully worked out by Ernst Hæckel, in his 'Monograph of Radiolaria,' which comprises the *Thalassicolla* of Huxley, and the *Acanthometra* of Müller, and the members of which

are chiefly remarkable for their siliceous spiculæ, or skeleton, and their wonderfully long and delicate pseudopodial threads, have long been thought to have allies in fresh water, in the person of the sun-animalcules (*Actinophrys*). But naturalists who have not watched the record of the proceedings of the Dublin Microscopical Club, published in the 'Quarterly Journal of Microscopical Science,' will have been quite unprepared for the astonishing revelation of several genera of these exquisite forms inhabiting the fresh-water pools on the Irish moors. Their discovery is due to that careful student Mr. William Archer. Dr. Focke, of Bremen, it is true, has this year noticed the occurrence of some of these forms in moor-pools in Germany, but Mr. Archer's notices are much earlier in date than his, though his extended paper is only now appearing. The largest form, which is a truly noble rhizopod, is as big as a large pin's head, with thread-like pseudopods extending to a much greater circumference; masses of siliceous spicula are disposed over the disc, which contains some dozen large spherical bodies of a bright-green colour. This form Mr. Archer names *Raphidiophrys viridis*; other genera are characterized by Mr. Archer, and coloured figures referred to. The chief point of difference between these fresh-water Radiolarians and the marine forms is the absence in the former of the central cyst or capsule, and the yellow cells which have been considered of characteristic importance in the group.

A New Vitreous Sponge.—One of the products of the deep dredging last year, in H.M.S. 'Lightning,' has been described to the Royal Society, by Professor Wyville Thomson, as *Holtenia Carpenteri*. It was dredged up from a depth of 530 fathoms with several other organisms, there being four genera of Vitreous Sponges. *Holtenia* is one of this new group of sponges, which Professor Thomson makes to include also the Ventriculites of the Chalk. The genus is named in honour of Mr. Holten, Governor of the Faroe Islands. The order is mainly characterized by the great variety and complexity of form of the spicules, which may apparently, with scarcely an exception, be referred to the sex-radiate stellate type, a form of spicule which does not appear to occur in any other order of sponges. The genus *Holtenia* is nearly allied to *Hyalonema*, and seems to resemble it in its mode of occurrence. Both genera live imbedded in the soft upper layer of the chalk-mud in which they are supported: *Holtenia*, by a delicate range of siliceous fibres which spread round it in all directions, increasing its surface without materially increasing its weight; *Hyalonema*, by a more consistent coil of spicules, which penetrates the mud vertically and anchors itself in a firmer layer. The vitreous sponges, Dr. Thomson observes, along with the living Rhizopods and other Protozoa, which enter largely into the composition of the upper layer of the chalk-mud, appear to be nourished

by the absorption through the external surface of their bodies of the assimilable organic matter which exists in appreciable quantity in all sea-water, and which is derived from the life and death of marine animals and plants, and in large quantity from the water of tropical rivers. One principal function of this vast sheet of the lowest type of animal life, which probably extends over the whole of the warmer regions of the sea, may probably be to diminish the loss of organic matter by gradual decomposition, and to aid in maintaining in the ocean the "balance of organic nature."

A translation of Fritz Müller's interesting study of Crustacean development, which he published under the title 'Für Darwin,' has been brought out by Mr. Murray, Mr. Dallas having efficiently acted the part of translator.

The British Hydroid Zoophytes, by the Rev. Thomas Hincks, is one of Mr. Van Voorst's beautiful series, and is worthy of its place in that renowned company. The illustrations are in the form of plates—very copious and very well executed by Mr. Tuffen West.

NOTICES OF SCIENTIFIC WORKS.

The Scenery of England and Wales; its Character and Origin, being an Attempt to trace the Nature of the Geological Causes, especially Denudation, by which the Physical Features of the Country have been produced. With 86 Woodcuts. By D. MACKINTOSH, F.G.S. 8vo. Pp. 399. London: Longmans and Co.

THIS is the title of a new work on Physical Geology by Mr. D. Mackintosh, F.G.S., who has, during the past five years, contributed many original articles upon this subject to the 'Quarterly Journal of the Geological Society,' the 'Geological Magazine,' &c. In pursuing his professional engagements as a lecturer on geology, &c., the author has travelled through the length and breadth of England and Wales, and devoted a large part of his time to making careful observations of all the most striking points of geological interest within his reach.

The book commences with a description of the causes of denudation and the origin of natural scenery in various parts of the world. The second and main portion of the work is devoted to a classification, description, and attempted explanation of the various forms or types of scenery in England and Wales, included under the heads Escarpments, Cwms, Combes or Corries, Passes, Longitudinal Valleys, and Transverse Gorges.

The third part is devoted to excursions to special places of geological interest in England and Wales.

Mr. Mackintosh, by his previous writings, had identified himself as an advocate of "Marine Denudation," and as strongly opposed to the modern school of "Subærialists," as an ultra example of whom we may cite Colonel George Greenwood, who has, in an amusing book (entitled 'Rain and Rivers'*) set forth his views, which are the very antithesis of those of Mr. Mackintosh, but nevertheless contain many excellent observations on Subærial Denudation.

In travelling East or West—from the plain of the Medway to the Great Orme's Head—or from Dawlish and Dartmoor in the South, to Morecambe Bay and Keswick in the North, Mr. Mackintosh points out that, from the present coast-lines to the top of Snowdon, the sea has left its mark on many a Scar and Crag, and that, in fancy at least, we may still hear its murmur in

* 2nd Edition, 1866. London: Longmans and Co.

many an ancient sea-worn cave and hollow now far removed above the roar and turmoil of its surging billows.

We are glad to find that, although Mr. Mackintosh advocates the sea as an efficient agent to produce geological changes, yet he does not ignore the action of other causes in modifying the earth's surface—as Ice, Snow, Frost, Rain and Rivers, Nature's untiring agents, slowly—maybe secretly—yet surely modifying the surface of our island, as certainly as the sea is ever changing the contour of our coasts.

Mr. Mackintosh's previous articles elicited rejoinders from many of our leading geologists, and no doubt his book will have a similar effect.

Some of the woodcuts to this work are very excellent; *e.g.* Wallow Crags; * Sea-worn Chink, Pendower Point; † the Peak of Snowdon (Fig. 31); Cheddar Cliffs, &c.; ‡ others owe their merit to their utility as diagrams; a few might be better drawn, the subjects being really fine, if well treated.

In a future edition we would suggest the elision of several pages in Book III. ("Excursions"), which are merely irrelevant §, and the substitution of a short "Itinerary," giving plain directions how best to reach the many places of geological interest mentioned by the author.

It is almost too late this year for the home tourist to avail himself of Mr. Mackintosh's guidance to the Welsh Mountains, or Coniston Crags, but no doubt next year he will find many of our readers who will gladly take a walk with him "over Malvern Wych at midnight" (although, as keen geologists, they might prefer the early dawn), or, knapsack on back, to start "from Llanberis to Snowdon, through the Pass, and by Llyn Llydaw,"—or, indeed, along any of the twenty routes he has laid down for their acceptance—sure of finding fresh air, hard walking, capital scenery, good appetites, and some very hard geological nuts to crack afterwards.

Spectrum Analysis.—Six Lectures delivered in 1868 before the Society of Apothecaries of London. By H. E. Roscoe, B.A., F.R.S. Macmillan and Co., 1869.

THIS is the most complete work on spectrum analysis which has yet appeared in the English language; and the author being one of the first popularizers of this branch of experimental analysis, is thoroughly competent to deal with all the varied ramifications into which it has branched of late years. Little was heard of spectro-

* P. 382.

† P. 55.

‡ P. 141.

§ *e.g.* pp. 303-4, "An episode," &c.; p. 299, "Unfounded Suspicions," and one or two other passages.

scopic researches, until Professor Roscoe communicated to the 'Philosophical Magazine' Messrs. Bunsen and Kirchhoff's paper, in which they announced the probable existence of some new elements discovered by its means; but since then, spectrum observations have been deemed one of the most powerful means of research, and have formed an intimate bond of union between two sciences which before had little in common—astronomy and chemistry. The book is based, as the title indicates, on a course of six lectures delivered in 1868; but it must by no means be concluded that the author has merely printed the lectures as delivered. They are not only rewritten, but a large amount of new matter—which could not well be compressed into the substance of an hour's lecture—is introduced in the form of an appendix, which is often longer than the lecture itself; references which were originally brief are here quoted in full; discoveries which have been made since the delivery of the lectures are incorporated with the text; and illustrations, whether diagrammatic or experimental, appear in the form of woodcuts and chromo-lithographs.

The first lecture is somewhat elementary, being devoted to the properties of light, the action of a prism, the various conditions of different portions of the spectrum, and an account of the fixed black lines which cross it. In the second lecture the ordinary phenomena of spectrum analyses as usually understood are described, and its marvellous delicacy, which is capable of appreciating the 180-millionth part of a grain of sodium, is enlarged upon. The description of the spectroscope and its uses concludes this lecture.

The third is a continuation of the same subject, and includes an historical sketch of the development of spectrum analysis, and an account of the four spectrogenic metals—caesium, rubidium, thallium, and indium. Some practical applications of spectrum observations are here given, including a very full account of the employment of the spectroscope in the determination of the right moment to stop the blast during the Bessemer process. Speaking of this, we are told that if the blast be continued for ten seconds after the carbon lines disappear from the field of view, or if it be discontinued ten seconds before that point is reached, the charge becomes either so viscid that it cannot be poured from the converter into the ladle from which it has to be transferred to the moulds, or it contains so much carbon as to crumble up like cast iron under the hammer.

Lecture IV. is devoted to the subject of the spectra of metals which are only to be observed by means of the electric arc or induction spark, and very carefully-reduced and well-executed maps of metallic spectra accompany this subject. The concluding lectures are mainly devoted to spectrum observations as applied to astronomy, and here are given many beautiful maps and chromo-litho-

graphs of solar, stellar, and nebular lines, together with terrestrial spectra for the sake of comparisons.

As we remarked above, this book is a useful addition to our scientific literature; the language is clear, and the reader is presented with a view of the subject derived from extensive Continental investigations, as well as researches which have been carried out in the United Kingdom. Indeed, Professor Roscoe's intimate acquaintance with foreign physicists occasionally leads him into the error of crediting foreign workers at the expense of his own countrymen. The book is not only valuable to men of science, but cannot fail to be also of great interest for the educated public. The recent brilliant discoveries which have been made by the spectrum into the constitution of the sun, dating from the solar eclipse of 1868, show that the prism of Newton in the hands of his successors is destined to form the basis of a method of analysis, embracing not only the solar system, but the whole material universe.

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THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

MEETING AT EXETER, AUGUST, 1869.

THE PRESIDENT'S ADDRESS.

THE past twelve months have been characterized by steady work rather than for many brilliant scientific results. Investigators have been rather collecting particulars than forming generalizations. The dominant scientific result of the year has been the extended knowledge which we have gained of the constitution of the sun and heavenly bodies, and this met with full recognition in the inaugural address of the President, G. G. Stokes, M.A., Sec. R.S., which was delivered in the Victoria Hall, Exeter, on the 18th of August.

After briefly alluding to the objects of the Association, the President gave some account of the most recent progress of science, selecting especially from those branches with which he was more familiar, some examples which might prove to be of pretty general interest. Amongst the various branches of physical science, Astronomy occupies in many respects a foremost rank. The science of astronomy is indebted to that of optics for the principles which regulate the construction of those optical instruments which are so essential to the astronomer. It repaid its debt by furnishing to optics a result which it is important we should keep in view in considering the nature of light. It is to astronomy that we are indebted for the first proof we obtained of the finite velocity of light, and for the first numerical determination of that enormous velocity. Astronomy, again, led, forty-four years later, to a second determination of that velocity in the remarkable phenomenon of aberration discovered by Bradley, a phenomenon presenting special points of interest in relation to the nature of light. If, in respect of these phenomena, optics received much aid from astronomy, the latter science has been indebted to the former for information which could not otherwise have been obtained. The motions and the masses of the heavenly bodies are revealed to us, more or less fully, by astronomical observations; but we could not thus become acquainted with the chemical nature of these distant objects. Yet, by the application of the spectroscope to the scrutiny of the heavenly bodies, evidence has been obtained of the existence therein of various elements known to us by the chemical examination of the materials of which our own earth is composed; and not only so, but light is thrown on the state in which matter is there existing, which, in the case of nebulae especially, led to the formation of new ideas respecting

their constitution, and the rectification of astronomical speculations previously entertained.

We are accustomed to apply to the stars the epithet *fixed*. Defining as fixity, invariability of position as estimated with reference to the stars as a whole, and comparing the position of any individual star with those of the stars in its neighbourhood, we find that some of the stars exhibit "proper motions"—show, that is, a progressive change of angular position as seen from the earth, or rather as they would be seen from the sun, which we may take for the mean annual place of the earth. This indicates linear motion in a direction transverse to the line joining the sun with the star. But how shall we determine whether any particular star is approaching to or receding from our sun? It is clear that astronomy alone is powerless to aid us here, since such a motion would be unaccompanied by change of angular position. Here the science of optics comes to our aid in a remarkable manner. Suppose that we were in possession of a source of light capable of exciting vibrations of a definite period, corresponding, therefore, to light of a definite refrangibility. Then, if the source of light and the observer were receding from or approaching to each other with a velocity which was not insensibly small compared with the velocity of light, an appreciable lowering or elevation of refrangibility would be produced, which would be capable of detection by means of a spectroscope of high dispersive power. The velocity of light is so enormous—about 185,000 miles per second—that it can readily be imagined that any motion which we can experimentally produce in a source of light is as rest in comparison. But the earth in its orbit round the sun moves at the rate of about 18 miles per second; and in the motions of stars approaching to or receding from our sun, we might expect to meet with velocities comparable with this. The orbital velocity of the earth is, it is true, only about the one ten-thousandth part of the velocity of light. Still the effect of such a velocity on the refrangibility of light, which admits of being easily calculated, proves not to be so insensibly small as to elude all chance of detection, provided only the observations are conducted with extreme delicacy.

But what evidence can we ever obtain, even if an examination of the light of the stars should present us with rays of definite refrangibility, of the existence in those remote bodies of ponderable matter vibrating in known periods not identical with those corresponding to the refrangibilities of the definite rays which we observe? The answer to this question will involve a reference to the splendid researches of Professor Kirchhoff, which led him to make a careful comparison of the places of the dark lines of the solar spectrum with those of bright lines produced by the incandescent gas or vapour of known elements; and the coincidences were in many

cases so remarkable as to establish almost to a certainty the existence of several of the known elements in the solar atmosphere, producing by their absorbing action the dark lines coinciding with the bright lines observed. Among other elements may be mentioned in particular hydrogen, the spectrum of which, when traversed by an electric discharge, shows a bright line or band exactly coinciding with the dark line C, and another with the line F.

Now Mr. Huggins found that several of the stars show in their spectra dark lines coinciding in position with C and F, and what strengthens the belief that this coincidence, or apparent coincidence, is not merely fortuitous, but is due to a common cause, is that the two lines are found associated together, both present or both absent. And Kirchhoff's theory suggests that the common cause is the existence of hydrogen in the atmospheres of the sun and certain stars, and its exercise of an absorbing action on the light emitted from beneath.

Now by careful and repeated observations with a telescope furnished with a spectroscope of high dispersive power, Mr. Huggins found that the F line, the one selected for observation, in the spectrum of Sirius, did not exactly coincide with the corresponding bright line of a hydrogen spark, which latter agrees in position with the solar F, but was a *little* less refrangible, while preserving the same general appearance.

Assuming, then, that the small difference of refrangibility observed between the solar F and that of Sirius is due to proper motion, Mr. Huggins concludes from his measures of the minute difference of position that, at the time of the observation, Sirius was receding from the earth at the rate of 41.4 miles per second. A part of this was due to the motion of the earth in its orbit, and on deducting the orbital velocity of the earth, resolved in the direction of a line drawn from the star, there remained 24.4 miles per second as the velocity with which Sirius and our sun are mutually receding from each other.

We turn now to another recent application of spectral analysis. Various expeditions were equipped for the purpose of observing the total solar eclipse which was to happen on the 17th August, 1868, and shortly before the conclusion of the meeting of the Association at Norwich last year, the first results of the observations were made known to the meeting, through the agency of the electric telegraph. In a telegram sent by M. Janssen to the President of the Royal Society, it was announced that the spectrum of the prominences was very remarkable, showing bright lines, while that of the corona showed none. The prominences could not be clouds in the strict sense of the term, shining either by virtue of their own heat or by light reflected from below. They must consist of incandescent matter in the gaseous form. It appears from more

detailed accounts that, except in the immediate neighbourhood of the sun, the light of the prominences consisted mainly of three bright lines, of which two coincided with C and F, and the intermediate one nearly, but, as subsequent researches showed, not exactly, with D. The bright lines coinciding with C and F indicate the presence of glowing hydrogen. Several of the other lines were identified with those which would be produced by the incandescent vapour of certain other elements.

Valuable as these observations were, it is obvious that we should have had long to wait before we could have become acquainted with the usual behaviour of these objects, and their possible relation to changes which may be going on at the surface of the sun, if we had been dependent on the rare and brief phenomenon of a total solar eclipse for gathering information respecting them. But how, the question might be asked, shall we ever be able so to subdue the overpowering glare of our great luminary, and the dazzling illumination which it produces in our atmosphere when we look nearly in its direction, as to perceive objects which are comparatively so faint? Here again the science of optics comes in aid of astronomy.

When a line of light, such as a narrow slit held in front of a luminous object, is viewed through a prism, the light is ordinarily spread out into a coloured band, the length of which may be increased at pleasure by substituting two or more prisms for the single prism. As the total quantity of light is not thereby increased, it is obvious that the intensity of the light of the coloured band will go on decreasing as the length increases. Such is the case with ordinary sources of light, like the flame of a candle or the sky, which give a continuous spectrum, or one generally continuous, though interrupted by dark bands; but if the light from the source be homogeneous, consisting, that is, of light of one degree of refrangibility only, the image of the slit will be merely deviated by the prisms, not widened out into a band, and not consequently reduced in intensity by the dispersion. And if the source of light emit light of both kinds, it will be easily understood that the images of the slit corresponding to light of any definite refrangibilities which the mixture may contain will stand out, by their superior intensity, on the weaker ground of the continuous spectrum.

Preparations for observations of the kind had long been in progress in the hands of Mr. Lockyer; and on the 20th of October last year, in examining the space immediately surrounding the edge of the solar disk, he obtained evidence, by the occurrence of a bright line in the spectrum, that his slit was on the image of one of those prominences, the nature of which had so long been an enigma. Notices of this discovery were received from the author by the Royal Society on October 21st and November 3rd. These were shortly afterwards followed by a fuller paper on the same subject.

Meanwhile the same thing had been independently observed in another part of the world. After having observed the remarkable spectrum of the prominences during the total eclipse, it occurred to M. Janssen that the same method might allow the prominences to be detected at any time; and on trial he succeeded in detecting them the very day after the eclipse. Shortly after Mr. Lockyer's communication of his discovery, Mr. Huggins, who had been independently engaged in the attempt to render the prominences visible by the aid of the spectroscope, succeeded in seeing a prominence as a whole by somewhat widening the slit, and using a red glass to diminish the glare of the light admitted by the slit, the prominence being seen by means of the C line in the red.

One of the most striking results of the habitual study of these prominences is the evidence they afford of the stupendous changes which are going on in the central body of our system. Prominences, the heights of which are to be measured by thousands and tens of thousands of miles, appear and disappear in the course of some minutes; and a study of certain minute changes in the bright line F, which receive a simple and natural explanation by referring them to proper motion in the glowing gas by which that line is produced, and which we see no other way of accounting for, has led Mr. Lockyer to conclude that the gas in question is sometimes travelling with velocities comparable with that of the earth in its orbit. Moreover these exhibitions of intense action are frequently found to be intimately connected with the spots, and can hardly fail to throw light on the disputed question of their formation. Nor are chemical composition and proper motion the only physical conditions of the gas which are accessible to spectral analysis. By comparing the breadth of the bright bands (for though narrow they are not mere lines) seen in the prominences with those observed in the spectrum of hydrogen rendered incandescent under different physical conditions, Dr. Frankland and Mr. Lockyer have deduced conclusions respecting the pressure to which the gas is subject in the neighbourhood of the sun.

The President next proceeded to congratulate the Association on the successful completion of the great Southern telescope, a description of which appeared in our pages a short time ago. The telescope, constructed by Mr. Grubb, of Dublin, is now erected at Melbourne, and in the hands of Mr. Le Sueur, who has been appointed to use it. Before its shipment it was inspected in Dublin by the committee appointed by the Royal Society to consider the best mode of carrying out the object for which the vote was made by the Melbourne legislature; and the committee speak in the highest terms of its contrivance and execution. We may expect before long to get a first instalment of the results obtained by a scrutiny of the southern heavens with an instrument far more

powerful than any that has hitherto been applied to them—results which will at the same time add to our existing knowledge and redound to the honour of the colony, by whose liberality this long-cherished object has at last been effected.

The results of the deep-sea dredging committee were then briefly alluded to; but as they will be found fully described in our *Chronicles* and in the reports of sections of the Association, it is unnecessary to dwell upon them in this place.

The President next referred to the Faraday Memorial, and stated that the present Chancellor of the Exchequer did not think it right that the recognition of scientific merit, however eminent, should fall on the taxation of the country, though even in a pecuniary point of view the country has received so much benefit from the labours of scientific men. The carrying out of the resolution passed by the Heads of the Learned Societies being thus left to private exertion, a public meeting, presided over by H.R.H. the Prince of Wales, was held in the Royal Institution, an establishment which has the honour of being identified with Faraday's scientific career. At this meeting a committee was formed to carry out the object, and a subscription list commenced.

In Chemistry, the speaker confined his attention to three discoveries. The first was the discovery of turacine, a red colouring matter extracted from the feathers of the turaco or plaitain-eater, which has been investigated by Professor Church, who finds it to contain nearly six per cent. of copper, which cannot be distinguished by the ordinary tests, nor removed from the colouring matter without destroying it. In the turaco the existence of the red colouring matter which belongs to their normal plumage is dependent upon copper, which, obtained in minute quantities with the food, is stored up in this strange manner in the system of the animal. This example warns us against taking too utilitarian a view of the plan of creation. Here we have a chemical substance elaborated which is perfectly unique in its nature, and contains a metal, the salts of which are ordinarily regarded as poisonous to animals, and the sole purpose to which, so far as we know, it is subservient in the animal economy is one of pure decoration. The second discovery was that of artificial alizarine, the colouring matter of madder; and the third the investigations of Dr. Matthiessen on the constitution of opium bases. These discoveries have been fully referred to in our *Chronicles*, and it is unnecessary to repeat the details here.*

In relation to mechanism, this year is remarkable as being the centenary of the great invention of our countryman James Watt. It was in the year 1769 that he took out his patent involving the

* See 'Journal of Science,' No. xxiii., p. 427, and No. xxiv., p. 530.

invention of separate condensation, which is justly regarded as forming the birth of the steam-engine. It needs no formal celebration to remind Britons of what they owe to Watt. Of him truly it may be said "*si monumentum requiras circumspice.*"

No other physical science has been brought to such perfection as mechanics; and in mechanics we have long been familiar with the idea of the perfect generality of its laws, of their applicability to bodies organic as well as inorganic, living as well as dead. But from mechanics let us pass on to chemistry, and the case will be found by no means so clear. When chemists ceased to be content with the mere ultimate analysis of organic substances, and set themselves to study their proximate constituents, a great number of definite chemical compounds were obtained which could not be formed artificially; but as the science progressed many of these organic substances were formed artificially, in some cases from other and perfectly distinct organic substances, in other cases actually from their elements; and we may say that at the present time a considerable number of what used to be regarded as essentially natural organic substances have been formed in the laboratory. That being the case, it seems most reasonable to suppose that in the plant or animal from which those organic substances were obtained, they were formed by the play of ordinary chemical affinity; and since the boundary-line between the natural substances which have and those which have not been formed artificially, is one which, so far as we know, simply depends upon the amount of our knowledge, and is continually changing as new processes are discovered, we are led to extend the same reasoning to the various chemical substances of which organic structures are made up.

Admitting this much, Professor Stokes proceeded to ask whether the laws of chemical affinity, together with those of capillary attraction, of diffusion, and so forth, account for the formation of an organic structure, as distinguished from the elaboration of the chemical substances of which it is composed? To this he replied decidedly No! No more than the laws of motion account for the union of oxygen and hydrogen to form water, though the ponderable matter so uniting is subject to the laws of motion during the act of union just as well as before or after. In the various processes of crystallization, of precipitation, and so forth, which we witness in dead matter, there is not the faintest shadow of an approach to the formation of an organic structure, still less to the wonderful series of changes which are concerned in the growth and perpetuation of even the lowliest plant. Admitting to the full, as highly probable, though not completely demonstrated, the applicability to living beings of the laws which have been ascertained with reference to dead matter, the speaker proceeded to say that he felt constrained at the same time to admit the existence of a mysterious *something*

lying beyond—a something *sui generis*, which he regarded not as balancing and suspending the ordinary physical laws, but as working with them and through them to the attainment of a designed end.

What this *something*, which we call life, may be, is a profound mystery. We know not how many links in the chain of secondary causation may yet remain behind; we know not how few. It would be presumptuous indeed to assume in any case that we had already reached the last link, and to charge with irreverence a fellow-worker who attempted to push his investigations yet one step farther back. On the other hand, if a thick darkness enshrouds all beyond, we have no right to assume it to be impossible that we should have reached even the last link of the chain—a stage where further progress is unattainable, and we can only refer the highest law at which we stopped to the fiat of an Almighty Power. To assume the contrary as a matter of necessity, is practically to remove the First Cause of all to an infinite distance from us. The boundary, however, between what is clearly known and what is veiled in impenetrable darkness is not ordinarily thus sharply defined. Between the two there lies a misty region, in which loom the ill-discerned forms of links of the chain which are yet beyond us; but the general principle is not affected thereby. Let us fearlessly trace the dependence of link on link as far as it may be given us to trace it, but let us take heed that in thus studying second causes we forget not the First Cause, nor shut our eyes to the wonderful proofs of design, which, in the study of organized beings especially, meet us at every turn.

Truth we know must be self-consistent, nor can one truth contradict another, even though the two may have been arrived at by totally different processes: in the one case, suppose, obtained by sound scientific investigation; in the other case, taken on trust from duly authenticated witnesses. None need fear the effect of scientific inquiry carried on in an honest, truth-loving, humble spirit, which makes us no less ready frankly to avow our ignorance of what we cannot explain than to accept conclusions based on sound evidence. The slow but the sure path of induction is open to us. Let us frame hypotheses if we will: most useful are they when kept in their proper place, as stimulating inquiry. Let us seek to confront them with observation and experiment, thereby confirming or upsetting them as the result may prove; but let us beware of placing them prematurely in the rank of ascertained truths, and building further conclusions on them as if they were.

The speaker concluded his long and eloquent address in the following words:—“When from the phenomena of life we pass on to those of mind, we enter a region still more profoundly mysterious. We can readily imagine that we *may* here be dealing with phenomena altogether transcending those of mere life, in some such way as

those of life transcend, as I have endeavoured to infer, those of chemistry and molecular attractions, or as the laws of chemical affinity in their turn transcend those of mere mechanics. Science can be expected to do but little to aid us here, since the instrument of research is itself the object of investigation. It can but enlighten us as to the depth of our ignorance, and lead us to look to a higher aid for that which most nearly concerns our well-being."

MATHEMATICAL AND PHYSICAL SCIENCE. (Section A.)

The meetings of this Section were opened on August 19th, by the President, Professor Sylvester, who, in his address confined himself mainly to combating the view advanced by Professor Huxley, that "mathematical training is almost purely deductive. The mathematician starts with a few simple propositions, the proof of which is so obvious that they are called self-evident, and the rest of his work consists of subtle deductions from them." And again that "mathematics is that study which knows nothing of observation, nothing of experiment, nothing of induction, nothing of causation." These statements were shown to be opposite to the facts of the case, and many instances were adduced to show that mathematical analysis is unceasingly calling forth the faculties of observation and comparison; that one of its leading features is induction; that it has frequently recourse to experimental trial and verification; and that it affords a boundless scope for the exercise of the highest efforts of imagination and invention. Rieman wrote a thesis to show that the basis of our conception of space is purely empirical, and our knowledge of its laws the result of observation; that other kinds of space might be conceived to exist, subject to laws different from those which govern the actual space in which we are immersed. Gauss called mathematics a science of the eye; and this great man was used to say that he had laid aside several questions which he had treated analytically, and hoped to apply to them geometrical methods in a future state of existence, when his conceptions of space should have become amplified and extended; for as we can conceive beings (like infinitely attenuated book-worms in an infinitely thin sheet of paper) which have only the notion of space of two dimensions, so we may imagine beings capable of realizing space of four or a greater number of dimensions.

Most, if not all, of the great ideas of modern mathematics have had their origin in observation. For instance, one gigantic outcome of modern analytical thought, itself, too, only the precursor and progenitor of a future still more heaven-reaching theory, which will comprise a complete study of the interoperation of algebraic

forms,—how did this originate? In the accidental observation by Eisenstein, some twenty years ago, of a single invariant (the quadrinvariant of a quartic), which he met with in the course of certain researches just as accidentally and unexpectedly as M. Du Chaillu might meet a gorilla in the country of the Fantees, or any one of us in London a white Polar bear escaped from the Zoological Gardens. Fortunately he pounced down upon his prey, and preserved it for the contemplation and study of future mathematicians. It occupies only part of a page in his collected posthumous works. This single result of observation (as well entitled to be so called as the discovery of globigerinæ in chalk, or of the confocal ellipsoid structure of the shells of the foraminifera), which remained infructuous in the hands of its eminent author, has served to set in motion a train of thought and propagated an impulse which have led to a complete revolution in the whole aspect of modern analysis, and will continue to be felt until mathematics are forgotten and British Associations meet no more.

The speaker continued:—"Were it not unbecoming to dilate on one's own personal experience, I could tell a story of almost romantic interest about my own latest researches (in a field where geometry, algebra, and the theory of numbers melt in a surprising manner into one another, like sunset tints, or the colours of the dying dolphin (the last still loveliest), a sketch of which has just appeared in the 'Proceedings of the London Mathematical Society,' which would very strikingly illustrate how much observation, divination, induction, experimental trial and verification, causation, too (if that means, as I suppose it must, mounting from phenomena to their reasons or causes of being), have to do with the work of the mathematician. In the face of these facts, which every analyst in this room or out of it can vouch for out of his own knowledge and personal experience, how can it be maintained in the words of Professor Huxley, who in this instance is speaking of the sciences as they are in themselves, and without any reference to scholastic discipline, that 'mathematics is that study which knows nothing of observation, nothing of induction, nothing of experiment, nothing of causation?'"

The speaker continued to say that he was not so absurd as to maintain that the habit of observation of *external nature* will be best, or at all, cultivated by the study of mathematics, at all events as that study is at present conducted, and no one could desire more earnestly than himself to see natural and experimental science introduced into our schools as a primary and indispensable branch of education; that study and mathematical culture should go on hand in hand together, and they would greatly influence each other for their mutual good. He should rejoice to see mathematics taught with that life and animation which the presence and example

of her young and buoyant sister could not fail to impart; short roads preferred to long ones; Euclid shelved or buried "deeper than did ever plummet sound;" morphology introduced into the elements of algebra; projection, correlation, motion, accepted as aids to geometry; the mind of the student quickened and elevated, and his faith awakened by early initiation into the ruling ideas of polarity, continuity, infinity, and familiarization with the doctrine of the imaginary and inconceivable. It is this living interest in the subject which is so wanting in our traditional and mediæval modes of teaching. Some people have been found to regard all mathematics after the 47th proposition of Euclid as a sort of morbid secretion, to be compared only with the mother-of-pearl generated in the deceased oyster; others find its justification, its "*raison d'être*," in its being either the torch-bearer leading the way, or the handmaiden holding up the train, of physical science; and a very clever writer, in a recent magazine article, expresses his doubts whether it is in itself a more serious pursuit or more worthy of interesting an intellectual human being than the study of chess problems or Chinese puzzles. But this is like judging of architecture from being shown some of the brick and mortar, or even a quarried stone of a public building; or of painting from the colours mixed on the palette; or of music by listening to the thin and screechy sounds produced by a bow passed haphazard over the strings of a violin. The world of ideas which it discloses or illuminates, the contemplation of divine beauty and order which it induces, the harmonious connection of its parts, the infinite hierarchy and absolute evidence of the truths with which it is concerned—these and such like are the true grounds of the title of mathematics to human regard, and would remain unimpaired were the plan of the universe unrolled like a map at our feet, and the mind of man qualified to take in the whole scheme at a glance.

At the conclusion of the above address the reading of the papers commenced. As it would be impossible to give within the limits at our command an intelligible abstract of the mathematical and some of the physical papers, we shall confine our reports to abstracts of those papers which will be of interest in their condensed form.

The first paper was the report of the Lunar Committee, read by the Secretary, Mr. W. R. Birt. Since the formation of the committee in 1864, a surface of 100 square degrees has been surveyed; the outlines of 433 objects have been laid down on a scale of 200 inches to the moon's diameter; and a catalogue has been prepared, containing notices of important phenomena bearing on the question of either transient or permanent lunar change. The report enters fully on this latter point, and, in conclusion, draws attention to certain differences between the photographs employed, particularly one with respect to a certain crater figured by Lohrmann, which is found

on De la Rue's, but not a vestige can be discovered on Rutherford's. Some attention has also been given to apparent changes of brightness and tint, a subject to which Webb called attention a few years since. Three or four somewhat conspicuous spots were adduced as exhibiting these alternations, which appear to be independent of any agencies with which we are acquainted.

Mr. W. R. Birt then read a paper "On Secular Variations of Lunar Tints." The author, in alluding to the importance of an examination of the tints of the lunar surface, remarked that to carry it out in its entirety would entail a most enormous labour, but he recommended that a few of the most prominent objects should be selected for the purpose. He called attention to the fact that changes of tint and brilliancy were common on the moon. These changes were generally referred to variations in the angle at which the sun's light fell upon the object. The author then proceeded to notice certain differences which have been observed between the tints of objects as recently determined, and those of the same objects as recorded by previous selenographers. We have the means of obtaining presumptive evidence of change of tint, independent of illumination, in the fact that if any two spots be taken, one being brighter than the other at a given epoch of illumination, should the order of brightness be reversed at any subsequent epoch, the illumination being the same, the legitimate conclusion would be that a change had occurred in the meantime; and, as being unconnected with any theoretical considerations of change, the author suggested the term "secular variation of tint" to designate such phenomena. In the concluding part of the paper the author referred to the number of spots which have been observed during the last forty-nine years on the lunar crater Plato.

In a communication "On the Lunar Crater Plato," W. R. Birt stated that certain peaks on the western wall of the crater had been measured by Beer and Maedler, the heights varying from 5000 to 7000 English feet. These peaks at sunrise cast well-defined long shadows on the floor, and these shadows had been measured by Professor Challis, of Cambridge. Mr. Birt compared delineations of the shadows by Professor Challis, the late Lord Rosse, the late Rev. W. R. Dawes, and J. Birmingham, Esq., of Millbrook Tuam, and finds some interesting results, among which may be named the proximity of the shadows of the three principal peaks to three very minute craters on the floor of Plato, thus furnishing a means of readily identifying these craters at any future time.

Mr. G. J. Symons presented the report of the committee on Underground Temperatures. The committee had tried experiments on underground temperatures at Glasgow, Dundee, and wherever they could get access to very deep wells or borings in the

earth. But the chief experiments had been tried in a well made many years ago at Kentish Town by a company formed for the purpose of supplying the district with water. The total depth in this instance was 1032 feet, 540 feet of which consisted of a bricked wall, and the remainder of a boring lined with thin sheet iron. The committee had obtained the use of the old well, and fitted up winding apparatus above it in a hut, to let specially-constructed thermometers up and down in the boring. The general result of the experiments was to prove an increase of temperature of one degree for every 52·4 feet increase in depth.

Dr. J. H. Gladstone gave an address on the Relation between the Refractive Energies and the Combining Proportions of the Metals. He pointed out that in most cases, but not all, the less the combining proportion of the metal, the greater is the refractive energy. The rule just mentioned does not hold at all with non-metallic elements, and proves most accurate with those metals which form good definite salts, such as magnesium, iron, and zinc.

Professor Gustav Magnus read a paper on the Reflection of Heat, in which he made known a discovery of his own, that fluor-spar has the property of reflecting, very largely, the dark invisible rays emitted by hot rock-salt. There is much evidence tending to prove that the heat-rays from rock-salt are of very great wave length, belonging almost to one of the extremities of the spectrum.

Lieut.-Colonel Strange, F.R.S., then spoke of the proceedings last year at Norwich, which resulted in the formation of a committee to determine whether there is adequate provision in Great Britain for the vigorous prosecution of scientific research. The committee had come unanimously to the conclusion that science had not adequate means for its vigorous prosecution. They submit, as the substance of their report, the recommendation that the full influence of the British Association for the Advancement of Science should at once be exerted to obtain the appointment of a Royal Commission to consider:—1. The character and value of existing institutions and facilities for scientific investigation, and the amount of time and money devoted to such purposes. 2. What modifications or augmentations of the means and facilities that are at present available for the maintenance and extension of science are requisite. 3. In what manner these can be best supplied.

Mr. J. P. Gassiot called attention to a curious dark deposit in certain vacuum tubes.

On Saturday the papers were almost wholly mathematical. On Monday the proceedings opened by the reading of several reports of committees. Admiral Sir E. Belcher read the report of a committee appointed to apply to the Admiralty for aid in observing

certain sea temperatures. The report pointed out that help in many cases was only offered on condition that the applicants employ clerks to search out the information required from the records, which expense the committee did not incur.

Mr. G. J. Symons read the report of the Rainfall Committee, which more especially pointed out the necessity for more stations of observation.

The report of the Tidal Committee was read by Mr. Rankine.

Mr. Glaisher read the report of the Association Committee on "Luminous Meteors." Large numbers of meteors had been seen during the past year. The report gave an account of an extraordinary meteor seen in France in October, which exploded with a detonation louder than any artillery, at, it was considered, a height of sixty miles. Much was said of the extensive observations made in America by Professor Newton and others. The report contained catalogues of all the meteors and aërolites observed. The radiant of the November meteors was well ascertained, but of the August meteors the radiant was not certain.

Dr. Neumayer read an abstract of a paper detailing the facts relating to the fall of a meteor a short time ago at Krähenberg. The fall took place in the day-time, and so great was the velocity of the mass that it buried itself two feet deep in the sandstone rock. It was dug out while still warm, and found to weigh $31\frac{1}{2}$ lbs. The sound was heard over a radius of thirteen miles.

Mr. Glaisher narrated the results of some meteorological experiments made in the car of the captive balloon. The principal fact was, that often when the air near the ground is quite still, and the smoke from the chimneys of the houses rising vertically, a hard gale is blowing aloft, and that at a height of less than 1000 feet.

The most important paper read on Monday was one by Mr. Whitworth, "On the Penetration of Armour-Plates by Shells with Heavy Bursting Charges fired obliquely," in which he set forth the superiority of the flat projectile over the pointed one for piercing armour-plated ships.

M. Janssen then described in French his method of obtaining views of the solar prominences at any time by means of a rapidly revolving slit and spectroscope.

A paper by Professor A. Morren, "On the Chemical Reaction of Light," discovered by Professor Tyndall, was then read. Professor Morren said that he had repeated Dr. Tyndall's celebrated experiments on the action of light upon vapours in tubes, but that, living in the south of France, he used the rays of the sun, instead of the light from the electric lamp. His tubes, like those of

Dr. Tyndall, were of glass, with flat glass ends, and glass stop-cocks. After exhausting the air from the tube, he permitted a mixture of absolutely pure dry hydrogen and nitrogen gas to enter, and on passing a cone of sunlight from a lens through the long axis of the tube, he was surprised to see a cloud forming, because of chemical decomposition set up. This led him to question the method employed to dry the gases, which was by passing them through powdered glass wetted with sulphuric acid. When chloride of calcium and other methods of drying gases were tried, no clouds were formed by the sunlight, so at last he came to the conclusion that a source of error lay in a trace of sulphurous acid gas, taken up by the hydrogen and the nitrogen from the sulphuric acid. The latter acid employed by him was absolutely pure, and contained no trace of arsenic from the use of impure sulphur in its manufacture. In the remainder of his paper he explained the exact nature of the chemical reactions which took place in his tube, which reactions he, like Dr. Tyndall, ascribed to a motion of separation set up between the atoms of each molecule, by the short blue and violet waves of the solar spectrum.

Mr. W. Huggins, F.R.S., read a paper "On the Heat of the Stars." The instruments used were a telescope, a very sensitive thermopile, and a galvanometer, by means of which faint indications of heat were obtained, accompanying the light from different stars.

Dr. Balfour Stewart F.R.S., read a paper on a very cleverly designed "New Rain Gauge," invented, made, and tested by Mr. Beckley, of Kew Observatory.

CHEMICAL SCIENCE. (Section B.)

The proceedings in this Section were opened by an address by the President, Dr. Debus, in which he reviewed the various directions in which chemical science was progressing, and directed attention to some of the fundamental ideas which guide chemists in their researches. The address was listened to with great attention, but is too technical to admit of more than this brief allusion to it. Most of the papers and reports communicated to this Section were on subjects of special more than general interest, and will not bear condensation. We will therefore select a few only of the papers which treat upon matters likely to be of general interest to our readers.

Dr. Jacobi read a paper on the "Electro Deposit of Iron," illustrating his remarks by a series of plates of extreme beauty. The solution from which the metallic iron was deposited consisted of a double sulphate of iron and magnesia. It was found desirable

to coat the recipient of the deposit with a thin film of nickel or copper.

The Committee on the Chemical Nature of Cast Iron reported that they entrusted the preparation of pure iron to Mr. Matthiessen, who expressed a hope that next year a great deal of very useful information will be obtained on the chemical nature and physical properties of pure iron and its alloys. Prof. Matthiessen then detailed very elaborately the nature and properties of pure iron, and the best methods for its preparation and fusion.

Professor Calvert, in some remarks upon the series of experiments conducted by him into the nature and condition of rust, stated that he thought the oxidation of the bottom of iron ships might be prevented by an external coating of an alloy of lead and antimony, and by placing an alkali in the bilge-water within the vessel.

Professor Tomlinson read a paper on the supposed Action of Light on Combustion. From a series of experiments upon candles of different sizes and weights in dark chambers and day and sun light, it was found that the increase of temperature alone led to increase of consumption of material; the final conclusion being that the direct light of the sun, or the diffused light of day, has no action on the rate of burning, or in retarding the combustion of an ordinary candle.

Mr. Walter Weldon read a long paper "On the Manufacture of Chlorine by means of perpetually regenerated Manganite of Calcium." What has hitherto been the ordinary process of manufacturing chlorine, consists in digesting ores containing peroxide of manganese with hydrochloric acid. The chloride of manganese, which is a residual product of this process, has hitherto been ordinarily thrown away. Mr. Weldon decomposes this chloride of manganese by lime, and then blows air through the resulting mixture. The protoxide of manganese absorbs oxygen from the injected air, thereby becoming converted into peroxide, which combines with the equivalent of lime used in excess, forming therewith the compound which the author calls manganite of calcium. The compound thus produced is employed instead of manganese ores for the liberation of chlorine from hydrochloric acid, and is then reproduced from the resulting solution of chloride of manganese, and so on continually, the same manganese being thus employed over and over again perpetually. Last year there were made in this country, and on the Continent, about 120,000 tons of bleaching-powder, and this bleaching-powder costs on an average about 5*l.* per ton for native oxide of manganese. Mr. Weldon's process produces bleaching-powder at a cost of only 15*s.* per ton for

manganite of calcium, and enables more chlorine to be obtained from a given quantity of hydrochloric acid than has hitherto been usually obtained therefrom.

Mr. Sorby sent a short note on Jargonia, in which he stated that zirconia was white, but that after ignition jargonia is of a clear straw-colour, paler than that of tungstic acid, but deeper than that of ceroso-ceric oxide.

Dr. Andrews read a short paper "On the Absorption Bands of Bile." A solution of bile in water or alcohol exhibits in the stereoscope well-marked absorption bands, which may be used as a characteristic test for the presence of bile, and even as a means of estimating approximately its amount in urine or other liquids having no absorption bands of their own.

Professor Janssen then delivered in French a discourse "On the Approximate Estimation of Sodium by Spectrum Analysis," which was followed by a discourse on the absorption of the rays of the spectrum by the vapour of water. Both these papers were copiously illustrated on the black board.

Mr. Spence then read a paper "On the Production of Higher Temperature by Steam of 212° Fahrenheit," and showed by experiment that the steam of boiling water at 212° , passing through a saturated solution of nitrate of soda, raised the temperature to 238° .

An interesting paper by Dr. Fritsche, a Russian chemist, "On the Structural Change in Block Tin," was read by Mr. Roberts, of Her Majesty's Mint. Dr. Fritsche found that the intense cold of St. Petersburg, during the winter of 1867, caused solid blocks of tin to crumble and fall into pieces. That the change was due to intense cold was proved by submitting blocks of tin to a temperature of -40° C., when the same structure was induced.

Our space will not enable us to do more than allude to several important papers on Water Supply and Utilization of Sewage, which were communicated by Dr. Paul, E. C. C. Stanford, and H. Bamber, and which are referred to at greater length in our report of Section G (Mechanical Science).

GEOLOGY. (SECTION C.)

Professor R. Harkness, F.R.S., the President of this Section, adopted for the subject of his opening address the Geology of Devonshire. He first spoke of the Pilton beds, which form the link between the Devonian and Carboniferous series, so well seen in this county, and which have been so ably investigated by Murchison and Sedgwick, Godwin-Austen, De la Beche, Lonsdale, Phillips,

&c., &c., &c. He pointed out their relation to certain beds in the south-west of Ireland, which were believed to occur in the same horizon as the Pilton shales. In referring to the labours of the Irish Geological Survey, the President paid a graceful tribute to the memory of Professor J. Beete Jukes, F.R.S., its late Director, whose active life has terminated since the publication of our last number. Among the latest labours of Mr. Jukes was the publication of a series of papers "On the Carboniferous Slate (or Devonian Rocks) and the Old Red Sandstone of South Ireland and North Devon;" "On North Devon and West Somerset," and "South Devon and Cornwall." There is reason to apprehend that the additional effort needed to carry out these and other extra-official scientific labours did much to curtail the life of one who was beloved by all who knew him, and whose loss we must all deeply regret.

Taking the Irish localities first, the President contrasted the Wexford district, with its 200 feet of Old Red Sandstones resting conformably on Cambrian strata, with Hook Point, Comeragh, Dungarvon, West County Cork, as far south-west as Glengariff and Killarney, where the unfossiliferous "Glengariff Grits" attain a thickness of 10,000 feet. Of all this vast thickness of sedimentary deposits, included in the Old Red Sandstone series in Ireland, only a thin band of Yellow Sandstones is fossiliferous, having yielded plants, mollusca, crustacea, and fishes.

This band (which is elsewhere reported upon by Mr. W. H. Bailey) occurs at Kiltorcan, co. Kilkenny.

Professor Harkness also showed the change which the Lower Limestone shales or Carboniferous slates undergo in passing south-westward from Hook Point, where their thickness is inconsiderable, to Cork Harbour and Kinsale, where they are 6500 feet in thickness, and where gritty beds make their appearance, which in Coomhola Glen attain a thickness of 3000 feet. These "Coomhola Grits" contain some peculiar fossils, and have others also common to the Carboniferous slates.

Returning to Devonshire, the President pointed out that to the north-east of Baggy Point hard purple sandstones occur (= to the Old Red Sandstones), overlain in North Devon by light-coloured beds, the equivalents of the "Yellow Sandstones" of Ireland; that above these again, at Marwood, were greenish-grey grits, with plant-remains (*Filicites linearis* and *Sagenaria Veltheimiana*), such as the base of the Carboniferous slates afford, these being identified with the "Coomhola Grits;" higher still, the Pilton beds had yielded fossils common also to the Carboniferous slates. He called attention to a common misapprehension existing among English geologists that the "Coomhola Grits" are *below* the base of the Carboniferous series, whereas they are truly a part of the Carboniferous slates.

He believed the difficulty of correlating the two areas arose

from the fact that the boundary line between the Devonian or Old Red Sandstones and the Carboniferous series had been placed in two different horizons. In Ireland the Carboniferous slates and inter-bedded "Coomhola Grits" form the base of the Carboniferous series; in England they are treated as belonging to the Devonian.

Professor Harkness then alluded to the Triassic pebble-bed at Budleigh Salterton, with its remnants of palæozoic fossils. He mentioned the recent discovery by Mr. Whitaker of reptilian remains, referred by Professor Huxley to *Hyperodapedon*. He drew attention to the Miocene Lignite beds of Bovey Tracey, the Flora of which has been so ably described by Dr. Oswald Heer, and the geology by Mr. Pengelly. Dr. Heer has identified many forms of plants with those which occur in the Miocene beds of Arctic America, Greenland, and Spitzbergen.

In referring to the exploration of Kent's Hole and similar ossiferous caverns, the President observed that geology and archæology were now shading into each other, and although the early history of mankind had long remained dim and indistinct like distant land, we were, by the labours of Lyell, Lubbock, and others, acquiring a clearer conception of early man, his mode of life and conditions of existence.

Mr. Godwin-Austen's paper "On the Devonian Group Considered Geologically and Geographically," dealt with the probable distribution of land and water during the Devonian epoch, and the effect of such conditions on the Fauna and Flora of the period. He spoke of the wide extent of the Devonian formation in Europe, Asia and America, and of the old Silurian land-surface which existed in the latter country during its deposition. From the fact that the fossil fishes of the Devonian belonged to the Ganoid family, the author inferred that a large portion of these beds were of lacustrine (fresh-water) origin; at the same time he admitted that vast marine accumulations were also simultaneously in process of formation in the adjoining seas. He spoke of the passage of the Old Red Sandstone group into the Silurian at its base, and into the Carboniferous series above, and concluded by indicating its easterly extension across Europe.

Dr. P. Martin Duncan presented his "Second Report on British Fossil Corals." After describing several new forms and referring to the 140 species already published, the author stated that 251 species of corals had been met with in British Secondary and Tertiary strata.

The author showed that not only are we able by the presence of certain corals to arrive at a correct estimate of the conditions of the seas of by-gone epochs, but also to trace out the ancient coast-lines by their coral reefs.

Mr. James Thomson exhibited the results of his labours in preparing sections of Carboniferous Limestone Corals, which, after being mounted on glass, have been photographed most successfully, so as to exhibit the most minute points of their structure.

Mr. G. W. Ormerod described the Granites of the northerly and easterly sides of Dartmoor. He mentioned that Schorl and Tourmaline are of frequent occurrence in these granites, but whether they were all of one age he was uncertain; the "elvans" or veins crossing the mass were undoubtedly of later age. Mr. Ormerod had not discovered any glacial striæ; but Dr. Otto Torell had examined the gravel near Hunt's Tor, and had declared it to be a true glacial moraine.

Mr. W. Pengelly, in a note on the "Source of the Miocene Clays of Bovey Tracey," showed that they were mostly formed of disintegrated granite, interstratified with the lignite beds.

Mr. T. Davidson's paper on "The Brachiopoda hitherto obtained from the 'Pebble-bed' of Budleigh Salterton," showed that the pebbles were a mixture of Devonian and Silurian strata, ten species belonging to each formation, and fifteen being new and undescribed forms. The fossil contents of the pebbles pointed to Normandy as the locality whence they had originally been derived.

Mr. Edward Hull traced the source of the Quartzose Conglomerates of the New Red Sandstone of central England (which in Lancashire and Cheshire attained the thickness of 700 feet) to the Old Red Sandstone formation. The pebbles were all liver-coloured quartzites, well rounded and water-worn, never sub-angular. The author considered they had gone through at least two periods of trituration. An examination of the Old Red Conglomerates near Loch Lomond fully confirmed his view as to their origin.

Mr. Henry Woodward gave an account of the Fresh-water Deposits of the Valley of the Lea in Essex, exposed in excavating the East London Waterworks Company's new reservoirs at Walthamstow. The excavations cover an area of 120 acres, and the materials removed are all of Post-Tertiary age, consisting of sand, clay, loam, peat, shell-marl, and river gravel. Twenty-six species of shells were identified, all of living species. The osseous remains include man, the wolf, fox, beaver, horse, wild boar, red deer, roebuck, fallow deer, reindeer, the elk, the goat, three species of oxen (*Bos primigenius*, *B. longifrons*, and *B. frontosus*), the sea-eagle, and some bones of fishes. In the deep trenches of the "puddle-walls" were found tusks of the mammoth and horns of the gigantic ox and deer. The presence of the reindeer, the elk, and the beaver, in so modern a deposit and so near to London is full of interest.

Mr. Pengelly presented the "Fifth Report of the Committee on the Exploration of Kent's Cavern." He stated that in the layer of black soil beneath the floor of the "vestibule" 366 flint implements had been obtained, together with flint cores, a bone needle, a bone harpoon or fish-spear, serrated on one side. Altogether 3948 boxes of bone fragments had been taken out, which Professor Boyd Dawkins had undertaken to examine. In the breccia beneath the cave-earth a flint flake had been discovered, associated with remains of the cave-lion, cave-bear, and mammoth.

Professor Boyd Dawkins gave some account of the animals. He stated that the men who lived in the cave when the black layer was being deposited were cannibals, split and gnawed human bones having been met with. He had identified in the lower layer bones of the glutton, the tailless hare, the beaver, &c.

Mr. H. H. Howorth communicated a very elaborate essay on "The Extinction of the Mammoth," in which he had collated all the statements respecting that animal to be found in the various works on Siberia, &c. He concluded that climatal conditions had extinguished the mammoth, and not the men of the Stone age.

Mr. Pengelly gave a short notice on the alleged occurrence of *Hippopotamus major* and *Machairodus latidens* in Kent's Hole. He showed good evidence of the latter animal's presence, but stated that the former had never been met with in this cavern.

Mr. W. H. Baily read the "Report of the Committee for the Exploration of the Devonian Beds of Kiltorcan, co. Kilkenny." A new fossil fern (*Adiantites*), a *Sagenaria* in fructification, and a new Limuloid Crustacean, were the most noteworthy results of this investigation, which we are glad to state is to be continued.

Mr. Charles Moore called attention to the occurrence of remains of *Teleosaurus* in the nodules of the Upper Lias at Ilminster.

Mr. George Maw's paper "On the Trappean Conglomerates of Middletown Hill, Montgomeryshire," furnished an excellent account of the Trap-rocks of Lower Silurian age which form this ridge, running parallel with the Breidden Hills on the borders of Shropshire and Montgomeryshire. Great beds of bouldered trap occur, composed of boulders of compact felstone imbedded in a matrix of felstone tuff. The interbedded traps are bounded on either side by Lower Llandeilo flags, and are collectively about 780 feet in thickness. Other eruptive beds were also noticed in this hill. The author suggested that the porphyritic greenstone of the Breidden Hills was probably emitted from the same point of eruption as these bedded traps. The local association of intrusive greenstones with interbedded felstones of Lower Silurian age, was stated to be very general in North Wales.

Mr. James Thomson's paper "On the Teeth and Dermal Structure of *Ctenacanthus* and on New Forms of *Pteropla* and other Carboniferous Labyrinthodonts, and of *Megalichthys*," was intended to prove that several so-called genera founded upon fossil fishes' teeth, were in reality only dermal spines. Mr. Thomson also showed that three or four existing genera could now be united in one. He exhibited a fine suite of Labyrinthodont and fish-remains, which he stated Professor Dr. Young would shortly describe.

Mr. W. Carruthers called attention to the occurrence of Reptilian eggs in the Stonesfield slate and in the Greensand of the Isle of Wight. They were forwarded to him as fossil fruits, and had a peculiarly glossy appearance, and the test was very thin.

Mr. Henry Woodward noticed (1) the occurrence of a new form of *Stylonurus* from the Cornstones of Herefordshire, and (2) the discovery of a large Myriapod (*Euphoberia Brownii*) in the Coal-measures of Kilmaurs, near Glasgow.

Mr. J. Randall's paper "On the Denudation of the Shropshire and Staffordshire Coal-fields," treated of the mineral character of some of the coal-seams, and also showed how several of them had been cut off by denudation. The author believed these fields were once continuous, but that they had been separated by denudation.

Dr. C. Le Neve Foster communicated a note on the occurrence of the mineral Scheelite at Val Toppa Gold Mine, near Domodossola, Piedmont. It is found associated with quartz, iron-pyrites, zinc-blende, calc-spar, brown-spar, and native gold. Scheelite (or tungstate of lime) is called "marmor-rosso" in Piedmont, and is looked upon as a good indication of the presence of gold.

Mr. John E. Taylor noticed certain phenomena in the Drift near Norwich. The contorted, furrowed, and displaced condition of the Boulder-clay and Drift beds, and the fractured and dislocated appearance of the Chalk along these lines of disturbance, could best, Mr. Taylor suggested, be explained by the action of icebergs.

A paper "On the Water-bearing Strata in the Neighbourhood of Norwich," by the same author, followed. It dealt with the origin of "sand-pipes" in the Chalk, and their action as natural drains, and the author gave an interesting statement of the effect of steam-power pumping in lowering the level of the wells around.

Mr. G. A. Lebour offered some Notes on the Denudation of Western Brittany, and on the Granites of Lower Brittany.

Dr. H. A. Nicholson contributed an account of some new forms of Graptolites from the Lower Silurian series.

Mr. Charles Moore's "Report on the Investigation of Veins containing Organic Remains which occur in the Mountain Limestone

of the Mendips and elsewhere," showed that these fissures must have remained open from a very early period, as they were found to contain Liassic and Carboniferous fossils, together with teeth of fishes. Mr. Moore had also discovered land and fresh-water shells, seeds of *Flemingites*, and large numbers of *Foraminifera* and *Entomostraca*. He considered that these discoveries must lead to an entirely new theory to explain mineral veins, as neither segregation nor thermal action could be reconciled with the presence of organic life in these fissures.

Mr. H. B. Brady noticed the *Foraminifera* discovered by Mr. Charles Moore, and especially referred to *Involutina*. The three genera mentioned by him were all still existing.

Mr. C. W. Peach recorded the discovery of *Orthoceratites*, Corals, &c., in the rocks between Nare Head and Porthalla Cove. This is the nearest point to the Land's End where Devonian fossils have yet been met with.

Mr. H. Bauerman, in reporting on Ice as an agent to produce Geological change, gave instances of the grooving power of ice as well as its ability to transport blocks and to form moraines. He thought that it would be necessary to obtain international scientific co-operation before accurate data could be brought together.

Mr. R. Brown adduced evidence to show that the west coast of Greenland was subsiding, and that points along the eastern coast had been elevated.

Mr. George Maw recorded the occurrence of insect-remains and fresh-water shells from the Lower Bagshot Leaf-bed of Studland Bay, Dorsetshire, not heretofore observed.

Dr. Henry Hicks gave an account of the discovery of Fossil Plants (?) in the Cambrian Rocks, near St. David's. In these Upper Longmynd rocks Dr. Hicks has met with many new species of Trilobites 1500 feet below the horizon at which organic remains had hitherto been found. He had also detected plant-remains, but they were doubtfully referred to plants, and were considered to be the tracks of Annelids and Trilobites by Professor Phillips and Mr. Etheridge. The importance of Dr. Hicks's discoveries is nevertheless very great, and we cannot but deeply regret that he has, by death, been deprived of the valuable co-operation of Mr. J. W. Salter (our highest authority on palaeozoic fossils) in carrying on these researches.

Dr. Mann gave a description of the Gold country of Natal, and the localities where the precious metal had been met with.

Mr. W. Stephen Mitchell presented the "Report of the Committee

for investigating the Leaf-beds of the Lower Bagshot series of the Hampshire Basin." Of the Alum Bay plants, Mr. Mitchell observed that the forms so abundant on the mainland were wanting here. *Aralias*, *Dryandras*, *Cussonias*, *Dalbergias*, &c., had turned up in great abundance, as well as Cinnamon plants. Although the last-named leaves appear to agree with some of the *Smilacææ*, he was fully convinced that they were true Cinnamons. The beds of Whitecliff Bay give promise of a still richer harvest. Specimens have also been obtained near Corfe. An accurate survey of these beds is being prepared to ascertain the relative levels of the Alum Bay and Mainland beds, under the superintendence of Mr. Mitchell.

Mr. Robert Etheridge described the occurrence of a large deposit of Terra-cotta Clay at Watcombe, Torquay. The clay, which is almost identical with that of Etruria, occupies a depression in the New Red Sandstone, which the author believed to have been a fresh-water lake wherein the deposit was accumulated. The clay is remarkable for its fine subdivision, and is of excellent quality for the production of fictile wares. It contains more than 60 per cent. of silica, 20 per cent of alumina, and 7 per cent. of peroxide of iron, also soda and potash salts.

Mr. J. Logan Lobley presented a very elaborate paper "On the Distribution of the British Fossil *Lamellibranchiata*," containing the results of a careful compilation of all the described species of fossil *Conchifera* in Great Britain, which, when printed *in extenso*, will furnish important Tables for the palæontologist and geologist.

Professor James Tennant gave an account of the Diamonds received from the Cape during the past year, the largest of which weighed $83\frac{1}{2}$ carats.

Mr. John Edward Lee called attention to some remarkable Glacial Striæ exposed at Portmadoc, in North Wales. These glaciated surfaces are by no means uncommon in Wales, but are frequently concealed beneath beds of drift. The present glaciated surface is very fine, but is being rapidly quarried away.

BIOLOGY. (Section D.)

When the Committee of this Section met on Wednesday the 18th, irrepressible Anthropology again led to a warm and somewhat personal discussion. A separate department of Physiology was proposed, and acceded to; but when Dr. Hunt* proposed that a department of Anthropology should also be formed, an objection

* Before the close of the meeting, Dr. Hunt left Exeter seriously ill, and it is with great regret we hear that he died a few days afterwards.

was made that there were not papers enough, and it was determined "that there be no department of Anthropology." Dr. Hunt then demanded that the papers which he had given in to be read before the department of Anthropology should be returned to him, but it was decided that they could be given up only on the personal application of the several authors. It was finally arranged that Monday, and if necessary Wednesday, be devoted to papers on Ethnology and Anthropology, and that the chief department of the Section have its title changed to "Zoology, Botany, and Ethnology." These arrangements were not however carried out, for on Tuesday and Wednesday Ethnological and Anthropological papers were read in a separate room, although the name of a "department" had been refused.

In the department of Zoology and Botany Mr. Spence Bate presided, and delivered a very interesting address "On the Physical Peculiarities of Devonshire and Cornwall." He alluded chiefly to the distribution of animals and plants; to the extreme mildness and uniformity of the climate; and to the interesting archæology of the district. The south-western peninsula was beyond the range of the nightingale; the glowworm might be seen shining in December; and strawberries were often gathered at Christmas. On the wastes of Dartmoor and the uncultivated lands of Cornwall stood many an unrecorded monument of antiquity. Year by year they were gradually passing away, and it appeared to him to be the duty of Ethnologists to explore all those which had not yet been accurately studied, and to take such steps as were necessary to preserve them all from destruction.

The business commenced with the "Report of the Committee on a Close-time for Birds," which was read by Mr. H. E. Dresser, and was followed by a paper by Rev. H. B. Tristram, "On the Effects of Legislation on the Extinction of Animals." The Report stated that the recent Act for the Preservation of Sea-fowl was a first step, and that it was advisable that it should be followed by legislation establishing a "close-time" for all birds (with a few special exceptions), as was the case in many countries of Europe and America. Mr. Tristram showed the effects of legislation, or the want of legislation, in causing the extinction of many animals. He argued that if man did not interfere, a balance would be established by nature which would be the best for all parties, and that by destroying birds and other animals considered to be noxious, man almost invariably produced greater evils than those which he tried to obviate. As an example, he might mention that the persistent raid of the gamekeepers against all birds of prey had led to such an increase of wood-pigeons in some parts of the country, that they caused a serious injury to the farmer by consuming large quantities

of grain. The sparrow-hawk was the only bird which could capture a wood-pigeon on the wing, and the gamekeepers destroyed this as well as kites and buzzards.

An animated discussion took place on both these papers. Professor Huxley strongly opposed all protective legislation, except in the one case of the salmon fishery, which he said was exceptional, because by placing nets across a river you could catch every salmon that was in it, and so exterminate them; but that this could not be done in the case of any other animal. He ridiculed the idea of the House of Commons adding to its other duties the protection of the whole British fauna and flora, about which it was so utterly ignorant; and believed that their tinkering could only lead to evil results. Sir John Lubbock, on the other hand, advocated such legislation, which he thought was both safe and useful, and thought that, considering the immense increase of our population and the extension of our towns and manufactures, we ought to do what we could to prevent the wilful and purposeless extermination by man of that variety of living things which added so much to the beauty and interest of our country. Mr. Wallace made some remarks on the accurate balance of the powers of offence and defence in nature, which led to all diseased or less perfectly organized creatures dying or being killed off, and to that appearance of perfect health and symmetry in all wild creatures, which was one of their charms as contrasted with domesticated animals. When man interfered with this balance, either by protection or extermination, imperfection and disease appeared, and rapidly spread; and he quite agreed with Mr. Tristram that the grouse disease would probably have been stamped out on its first appearance, had not the sanatory police of nature, the birds of prey, been so greatly reduced by man. Drs. Hooker and Scott and Messrs. Hanbury, Newton, Norman, Dalrymple, E. Bowring, and Miss Becker, also took part in the discussion.

Mr. Hallett, the producer of the celebrated "pedigree wheat," read a paper "On the Law of the Development of Cereals;" in which he stated that, after twenty years of observation and experiment, he had arrived at the conclusion that every fully developed plant of wheat, oats, or barley presents one ear finer than all the rest, and in that ear one grain superior in productive power to all the rest. This superiority is transmissible, and thus we at last arrive at and maintain a grain of the best quality and highest productive powers.

Some Botanical papers of less general interest were afterwards read.

On Friday the entire Section met in one room to hear papers of general interest. Dr. Dickson first exhibited some abnormal

Primulas, in which the style and stamens were either both long or both short—a fact difficult to account for on the theory of reversion, as both could not be the original form.

The Rev. A. M. Norman then read an account of the recent successful dredgings in the 'Porcupine,' in a letter from Professor Wyville Thomson, prefacing it with a sketch of what had been already done in deep-sea dredging. In the first excursion this season Mr. Gwyn Jeffreys had dredged in 1472 fathoms; but Professor Wyville Thomson, finding the weather very fine, proceeded to the deep water off the Bay of Biscay, and succeeded in bringing up $1\frac{1}{2}$ cwt. of ooze from the enormous depth of 2435 fathoms, with a bottom temperature of $36^{\circ}5$ Fahr. Subsequently, at 2090 fathoms, 2 cwt. of chalk-mud was brought up. These dredgings contained a fine *Dentalium* and other mollusca, crustaceans, annelids, crinoids, and starfishes, demonstrating the existence of all the higher forms of marine life in the deep abysses of the ocean. The dredge was down three hours. From careful temperature observations it was found that the effects of solar heat did not reach farther than 20 fathoms, while some other extraneous source of heat, probably that of the Gulf-stream, was detected as far as 500 to 700 fathoms; after that the temperature decreased $0^{\circ}2$ for each 200 fathoms, which was probably its normal rate. The deep water was analyzed, and found to contain an excess of oxygen and of organic matter, thus explaining the source whence the living jelly of the ooze, *Bathybius*, derived its nourishment.

In from 500 to 700 fathoms water *Cidaris* was abundant, as well as vitreous sponges in great variety and of many new types, and organisms allied to Ventriculites, thus exhibiting a series of forms strikingly similar to those characteristic of the true Chalk formation. As this chalky ooze was now known to extend over the bed of all the great oceans, it was a fair presumption that this peculiar substance had been forming continuously, somewhere or other, from the Cretaceous epoch to the present day; and as many of the characteristic forms of the chalk (although of distinct species) were proved to be still in existence, it was very possible that some of the chalk deposits of the globe might be of various intermediate ages between the Cretaceous and recent epochs.

Professor Huxley, Dr. Hooker, and Dr. Percival Wright took part in the discussion, the former adverting to the immense interest of the discovery that the direct descendants of chalk fossils were now in existence almost unchanged; and Dr. Hooker claiming that Captain Ross's Antarctic dredgings had first demonstrated the variety and abundance of deep-sea life, and had disproved Edward Forbes' celebrated theory even before it had appeared.

The greater part of Friday was occupied by Archdeacon Freeman, Rev. F. O. Morris, and Dr. McCann, who read papers opposed to Darwinianism and Evolutionism. The Archdeacon's paper was simply a sermon, treating every statement in the Mosaical account of the Creation as a fact of equal value with the facts observed by naturalists, and dwelling mainly on "those mysterious four-footed creatures, the cherubim," which it was maintained were the antitypes of all created things. Mr. Morris brought forward the usual old objections to Mr. Darwin's views, such as the assertion that varieties only last so long as artificial culture is continued; and the supposed inextricable dilemma that immigrants into a new country must be either adapted or not adapted to their new conditions; if adapted, why should they change? if not adapted, how could they exist till they changed? Dr. McCann's paper was a vigorous and able attack on Professor Huxley's celebrated article "On the Physical Basis of Life," which, as it will no doubt be published in full, it is unnecessary to say more about here than that it contained some very hard and telling hits at the weak points in the Professor's philosophy. Great interest was manifested in Professor Huxley's reply, which consisted, however, more of sarcasm than of argument. Dr. Hocker, Messrs. Vivian, Wallace, and others also spoke, and much surprise was expressed that the time of the Section should have been occupied by papers which ought never to have been admitted, since they either transgressed the limits of scientific inquiry or contained nothing original.

When the Section again descended to the level of Natural History science, Professor E. Percival Wright described a new shark of a monstrous size, which he had discovered at the Seychelle Islands, and which he named *Rhinodon typicus*. He saw specimens which he computed to be sixty feet long, although he could only obtain smaller ones for examination, and these appeared to subsist entirely upon sea-weed.

Miss Lydia Becker read a paper "On Alteration in the Structure of *Lychnis diurna* observed in connection with the Development of a Parasitic Fungus." This was a curious case of the occurrence of bisexual plants of which the anthers were attacked by a fungus which gave them a purple colour; this fungus only attacking the hermaphrodite and not the male plants, Miss Becker supposed that the fungus was the cause of the development of the pistil in what would otherwise have been unisexual male plants. Professor Balfour and Drs. Dixon and Wilks took part in the discussion, and while they all admitted the value and interest of Miss Becker's observations, did not agree with her interpretation of the facts. They could not, however, offer any more satisfactory expla-

nation of the phenomena, and waited for further observations to clear up the difficulty.

Mr. T. Blandford read a paper "On the relations of the Fauna of British India to that of the Ethiopian and so-called Indian Regions." He showed that the Indian peninsula could be divided into several districts characterized by the predominance of African, Malayan, or purely Indian types.

Mr. W. F. Webb gave his "Five Years' Experience of Artificial Fish-breeding, showing in what waters Trout will and will not thrive." He believed it was a question of the temperature of the water, which required to be cool and equable.

Mr. Frank Buckland then gave an account of "The Salmon Rivers of Devon and Cornwall," in his usual humorous and impressive style, offering many suggestions for their improvement by purification, clearing away obstructions, forming spawning beds, and by artificial hatching.

Mr. Antonio Brady exhibited some specimens of Gum Anime from Zanzibar, containing insects and a lizard. It was found in sandy deposits where there are now no trees, and is probably of high antiquity.

Mr. Spence Bate read an elaborate report "On the Marine Fauna and Flora of the South Coast of Devon and Cornwall," describing the new and rare species which have been recently obtained.

Other papers read were, "On a Variety or Hybrid of *Perdia cinerea*," by Dr. Scott; "On Initial Life—Infusoria," by Mr. C. S. Wake; "On the Remains of a Whale washed ashore at Bab-bicombe, South Devon," by Mr. Pengelly; "On the Mammalian Fauna of North-West America," by Mr. Robert Brown, F.R.G.S.; "On the Land and Fresh-water Shells of Nicaragua," by Mr. Ralph Tate, F.G.S.; and "On some curious Fossil Fungi from the Black Shale of the Northumberland Coal-fields," by A. Hancock, F.L.S., and Thomas Atthey.

In the department of Anatomy and Physiology, Mr. Busk presided. The first paper was Dr. Richardson's Report "On the Physiological Action of the Methyl Series," a subject whose chief interest was medical.

Mr. E. Ray Lankester read a report "On the Spectroscopic Examination of Animal Substances." He first explained the methods of studying absorption spectra, and the value of the evidence they afforded in physiological research. He then discussed the distribution of Hæmoglobin (the red oxygen-condensing matter of the blood corpuscles) in the animal kingdom, showing it to be

present in certain Molluscs, aquatic insect larvæ, a Phyllopodous Crustacean, many Annelids, and in all Vertebrata, as well as in the muscles of Mammals, Birds, and Fishes. The action of reagents on Hæmoglobin was then described, and the various derivative spectra obtained by other observers were compared, and their place in the spectrum scale fixed. Chlorocruorin, the green blood-stuff discovered by Mr. Lankester in *Siphonostoma* and *Sabella*, and Chondriochlor, the chlorophyl-like body obtained from *Spongilla fluviatilis*, were also fully described.

Dr. Wilson's paper "On the Moral Imbecility of Habitual Criminals," exemplified by Cranial Measurements, attracted a considerable audience. The author maintained that the majority of such criminals were devoid of all moral sense and principle, and could rarely distinguish between right and wrong. They exhibited a tendency to revert to the types of the uncivilized races, and cranial deficiency was associated with real physical deterioration. The habitual criminal was the victim of inherited proclivities to which he must yield, and of a course of training which had so warped his nature that he was incapable of appreciating any code of morality which did not harmonize with his own vicious tendencies. Dr. Wilson had examined and measured about 460 heads, and had arrived at the conclusion that habitual criminals were cranially deficient, especially in the anterior lobes of the cerebral portion of the brain.

The Rev. W. Caine, chaplain of the county gaol of Manchester, maintained that ignorance and defective intellect was by no means a universal or even general characteristic of criminals; and he startled the meeting by the statement that at one time, out of 700 Protestant criminals in the gaol, 81 were Sunday-school teachers, besides clergymen and their sons, solicitors, schoolmasters by the dozen, commercial travellers, and others. From very recent observation, he found that out of 649 criminals in that gaol 593 had been Sunday scholars, on the average between six and seven years each. This state of things arose from the bad example of parents and companions, and the temptation of drink.

Mr. Busk, Professor McClellan, and Mr. Prideaux also took part in the discussion, which turned much upon the cranial measurements; and it appeared, from the contradictory opinions held by the speakers, that all our collections of crania, their measurement and delineation, have yet led to very little result. We had thought, that however much the details had been disputed, the basis of Phrenology, that the brain is the organ of the mind, and that its anterior portion is the seat of the intellect, was pretty generally admitted. Mr. Busk and Prof. McClellan, however, assured the audience that there was much to be said on the other side, and that they inclined to the belief that the intellectual faculties had their seat in the back

part of the head, and that the broad expansive forehead had nothing whatever to do with the supremacy of human intellect.

Dr. Henry Blanc, Staff Assistant-surgeon. Bengal Army, read a paper "On Human Vaccine Lymph and Heifer Lymph compared." He believed it was an established fact that certain skin diseases and syphilis were transmitted by humanized lymph, and that such humanized lymph in time lost its power as a preventive of small-pox. He supported these positions by copious references to facts and authorities, and proposed vaccination direct from the heifer as the only remedy for these evils. By this alone could they render vaccination efficacious, and restore the usefulness and prestige of Jenner's great remedy.

Other papers were, a "Report on Chloral," by Dr. Richardson; "On the Occasional Definition of the Convulsions of the Brain on the Exterior of the Head," by Dr. T. S. Prideaux; "On the Interpretation of the Limbs and the Lower Jaw," by Professor Cleland; and "On Voltaic Electricity in relation to Physiology," by Mr. Bridgman.

Mr. E. B. Tylor presided over the Ethnological and Anthropological meetings. Sir John Lubbock's paper on "The Primitive Condition of Man; being some Remarks in answer to the Speculations of the Duke of Argyll," attracted a crowded audience. This was an elaborate essay, of which it is impossible to give a brief abstract. Its main object was to show that man had steadily progressed from an early state of moral and mental as well as social barbarism, and that knowledge meant civilization, ignorance barbarism. The Duke of Argyll, on the other hand, had maintained that there was no necessary connection between a state of childhood, as regards knowledge, and a state of barbarism, and that some of the worst savages were the descendants of more civilized races. Sir George Grey was inclined to support Archbishop Whateley and the Duke of Argyll. He had witnessed in London scenes of barbarism such as he had never met with among savage nations. He believed civilization was inseparable from religious feeling, and this did not depend upon material progress. Mr. Howorth gave instances of nations in Eastern Asia which had undoubtedly degenerated. Mr. Wallace admitted that the evidence was overwhelming for a steady advance in knowledge and intellect, but doubted if there was any similar evidence of an equal advance in moral feeling. Savages possessed a moral sense which influenced them just as much as it influenced civilized people. Knowledge and civilization gave to morality a wider sphere of action, but the sense or feeling itself did not appear to be more generally diffused or more active in civilized than in savage man. Dr. Blanc, Sir

Walter James, Messrs. Evans, Boyd Dawkins, and others also took part in the debate.

Dr. P. M. Duncan read a paper "On the Age of the Human Remains in the Cave of Cro-Magnon, in the Valley of the Vezere." In this cave four distinct layers of charcoal or ancient hearths had been found, containing bones of the mammoth and reindeer mixed with human bones; and Dr. Duncan argued that the circumstances were such as to indicate that this case did not prove man to be contemporary with the mammoth, since the bones might have been brought to the cave by hunters at a later period.

Col. Lane Fox then described his discovery of flint implements at Acton and other places in the valley of the Thames, in gravels, a hundred feet above the present river, at which level it had undoubtedly flowed when the gravel was deposited.

A Crannoge or lake-village in South Wales was described in a paper by the Rev. Mr. Dumbleton. It was situated in the Lake of Llangorse, and was very similar in construction to some of the Swiss lake-villages. Some of the piles were exhibited, as well as bones of the horse, ox, sheep, and wild boar, which were found there.

Mr. Lewis read a paper "On the Builders and Purposes of Megalithic Monuments." He said there existed a practically unbroken chain of megalithic monuments extending from India to Great Britain. Who were their builders? Identity of place and other traces of affinity led to the conclusion that there must have been at least a great common influence at work, though possibly not an absolute community of race. He held that they were probably constructed under Celtic influences—that the single upright stones were used as memorial pillars, the circles and alignments primarily as places of sacrifice, and the dolmens or table-stones, of which there were two well-marked varieties, in one view as places of sepulture, and in the other for purposes of sacrifice or memorial.

Many other papers were read before this department, which we have only space to mention. Sir Duncan Gibb had three,—“On the Paucity of Aboriginal Monuments in Canada,” which he imputed chiefly to the severity of the climate; “On an Obstacle to Longevity beyond Seventy Years,” which he found to be pendency of the epiglottis; and “On a Cause of Diminished Longevity among the Jews,” namely, eating too much fat and oil: “On the Primeval Status of Man,” by Mr. W. C. Dendy, was a somewhat vague essay on the origin of man, opposing the views of Huxley and Darwin, and leading to a long and rambling discussion; “On the Westerly Drifting of Nomades from the Fifth to the Nineteenth Century,” by Mr. H. H. Howarth; “The Origin of the Tasmanians,” by Mr. J. Bonwick; “The Natives of Vancouver’s

Island and British Columbia," by Dr. King; "On the Esquimaux considered in their relationship to Man's Antiquity," by Capt. W. S. Hall; "On Human Remains in the Gravels of Leicestershire," by Mr. Francis Drake, F.G.S.; "On the Method of forming Flint Flakes by the early Inhabitants of Devonshire," by Mr. F. M. Hall; "On the Frontier Line of Ethnology and Geology," by Mr. H. H. Howarth; "On the Brain of a Negro," by Mr. R. Garner; and "On the Race Elements of the Irish People," by Mr. G. H. Kinahan.

GEOGRAPHY. (Section E.)

Ethnology having this year been transferred to Section D, Section E was devoted exclusively to Geography. The meetings were held in the new Victoria Hall, and were presided over by Sir Bartle Frere, who, as Sir Andrew Waugh said during a discussion on one of the papers, proved his capacity not only to govern a great empire, but also to worthily fill Sir Roderick Murchison's chair. Though the Ethnological papers and discussions did not offer the attractions which had marked the proceedings of previous years, though the veteran President of the Royal Geographical Society was not present to add to its *prestige*, and though there were no Bakers, nor Palgraves, nor Livingstones present to give it additional *éclat*, the Section yet maintained its usual popularity, and was daily attended by a large and attentive audience. Papers were read by both English and foreign geographers, whose renown is more than European; and the discussions were often carried on by men distinguished not less for their statesmanship than for their scientific accomplishments. The papers were generally purely geographical; they were not merely descriptive, but frequently partook of a truly scientific character. Now and then, however, the political element could not be altogether repressed, and on these occasions the discussions turned on questions which are regarded by the general public with more than ordinary interest.

Though Sir Bartle Frere, in his opening address, disclaimed the intention "to attempt any systematic summary of the progress, present state, or prospects of Geographical science generally," he yet showed what was being done by geographers in all parts of the world, but dwelt, as might be expected, more on Asia than on any other continent. After referring with satisfaction to the presence at the meeting of more than one geographer who would represent that vast Russian empire which is gradually extending its borders in Central Asia, Sir Bartle pointed out that this magnificent region is little changed, save in political condition, since it was a nursery of great nations and a centre of civilization. "Here were nurtured,"

he said, "not only kings and founders of empires, but trains of thought and vast systems of moral and political philosophy, which have largely subdued and influenced the richer regions of the South and West. What," he asked, in continuation, "has inflicted on countries once so famous such a curse that the solitary traveller who passes through them, as Vambéry did, in disguise, is welcomed among us as one just escaped from almost certain death, who has during his whole sojourn carried his life in his hand?" He then expressed an opinion that nothing but good could result from the attention of English and Russian statesmen being directed to the condition of those countries and peoples which intervene between the boundaries of the two empires. The character of the papers relating to Asia which would be read by Mr. Douglas Forsyth, Mr. Trelawney Saunders, and others, were then explained, and a brief sketch given, with a summary of results, of the various attempts which have been made during the year to explore the central portion of the vast continent under consideration. The whereabouts of Dr. Livingstone was also naturally discussed; but Sir Bartle said that since the last meeting the evidence received has been purely negative; and "we still only know that, up to December, 1867, he was alive and well, and in good spirits, travelling westward from the neighbourhood of Lake Nyassa, and that he disappeared in the obscurity of the regions beyond." Further than this all is conjecture—whether we shall hear of him on the Nile, on the Congo, or at Zanzibar, is at present a pure subject of speculation. Mr. Erskine's explorations on the Lower Limpopo, Mr. Winwood Reade's journey towards the sources of the Niger, Mr. Chandless's explorations on the tributaries of the Amazons, and other interesting subjects were successively referred to; and Sir Bartle concluded his address with the expression of his satisfaction at the presence among them of such eminent foreign geographers as M. Khanikof, M. Pierre de Tchihatchef, and Chevalier Cristoforo Negri, the "Murchison of Italy."

The first paper read in the Section after the President's address on Thursday, was by Dr. R. J. Mann, "On the Position of the Mouth of the Limpopo." In this paper Dr. Mann explained that his friend, Mr. St. Vincent Erskine, the son of the Colonial Secretary of Natal, had settled a point which had long been disputed about by geographers, and by a remarkably adventurous and dangerous journey had shown what really was the outlet of the great African river into the ocean. The mouth of the stream at full tide was found to be 300 yards wide; and a succession of small rollers which broke over the shore indicated a shoal coast. There was a broad lagoon, shut in by a bar of dry sand, except where the river ploughed through it in a comparatively narrow channel. Mr. Erskine took an observation of the altitude of the sun at noon,

and found the position of the mouth of the Limpopo to be $25^{\circ} 15'$ South, but was unable to get the longitude, owing to the difficulties of transit having compelled him to abandon his instrument. The value of a "Small Altazimuth Instrument for the use of Explorers"—a description of which by Colonel Strange concluded the day's proceedings—was here made manifest, as by its means Mr. Erskine would have been enabled to fix his position with the greatest ease and accuracy.

The second paper was by Dr. Beke, and was entitled, "Plan of a Canal to unite the Upper Nile with the Red Sea." The idea conveyed in this paper is not new, a sovereign of Ethiopia having, several centuries ago, threatened to carry out a similar "plan," in order to be revenged on the ruler of Egypt. The notion is that a canal might be formed along a natural watercourse, and that the Atbara—"the black mother of Egypt," as Sir Samuel Baker calls the river—might be diverted to the Red Sea. The Nilotic fertilization being thus turned in another direction, Egypt would speedily become a desert. Sir Bartle Frere thought the paper did not contain such an impracticable suggestion as might at first sight appear; but Dr. Blanc, one of the late captives in Abyssinia, considered the difficulties in the way of the construction and navigation of the canal to be insuperable.

"A Visit to the Holy City of Fas, in Morocco," by Mr. J. Stirling, was next read. The author visited Fas in the suite of Sir J. Drummond Hay, the British Minister, in November last; the party being, it is said, the only Europeans, with the exception of Lord St. Maur, the eldest son of the Duke of Somerset, who have visited the city in modern times. The place once served Moorish pilgrims as a substitute for Mecca, hence probably the term "holy." Fas is fortified, and well situated on a tributary of the river Sebu. The population of the city could not be accurately ascertained, but Mr. Stirling estimated it at somewhat less than 100,000.

Captain T. P. White, R.E., furnished a paper on a "Bifurcating Stream in Perthshire;" and Captain C. Dodd gave some "Notes on a Recent Visit to the Suez Canal."

The second day's proceedings commenced with a description, by the President, of "The Runn of Cutch and the Countries between Rajpootana and Sind." Sir Bartle had visited this singular tract of country in the exercise of his official duties. It forms a great belt, with neither mountain ranges nor river systems; yet it cannot be called a plain, for it is ridged into sand-hills, nor can it be designated a desert, since it is everywhere inhabited, and in some parts supports a considerable fixed population and numerous herds of cattle. Cutch is a district about 600 miles long, its breadth

varying from 70 to 150 miles. It is divided into two great portions, the southern portion, generally marked as a morass, being the "Runn;" the northern part consisting of sand-hills, which the people consider to have been formed by the wind, but which Sir Bartle Frere considers to have been formed by subterranean forces, by the upheaval of the earth during an earthquake. The people inhabiting this district are much attached to their sand-hills, and possess a lowly kind of civilization. The Runn is not a bog, as seems sometimes to be considered, but a perfectly flat, hard plain, formed of sand and clay, the surface being so hard that the hoofs of a horse galloping over it would scarcely leave their impress behind. If rain falls, it finds no outlet, but remains until evaporated, and becomes salt through the extreme saline nature of the surface. No animals, vegetables, hollows, nothing that might be expected to be seen on any part of the earth's surface, can be found in this curious district. It is also destitute of landmarks, and travellers perform their journeys by night, guiding themselves by the stars, and in one part, by a fire which is lighted and kept burning on a hill by a family residing near the spot. The Runn is subject to periodical inundations by the waters of the Indian Ocean; several rivers also discharge themselves into it on the eastern side, but the water is seldom more than three feet deep. The character of the mirage in this district is extraordinary during the dry season, and the deceptive resemblance to a large and magnificent city with its palaces and towers is often seen. Sir Bartle Frere said he would not pretend to solve the problem how this peculiar table-like district was formed, but would "hazard the conjecture that it was somehow connected with the constant vibration caused by the very active and persistent volcanic action, evidence of which was found in the country around the basin, formed on the one side by the Thurr, and on the south by the semicircular land and Cutch proper. There could be no doubt that volcanic action all around there was more active than in any other part of the world." In attributing the peculiar geological phenomena to volcanic action, Sir Andrew Waugh agreed with the President; but Sir Charles Trevelyan thought with the natives that the sand-hills in the north-western part were more or less connected with the wind.

A paper, entitled "On the Latitude of Samarcand," and read in French by M. Nicholas de Khanikof, followed. M. de Khanikof visited the famous capital of Tamerlane in 1841, being, next to his companion, Lehmann, the first European who had seen it since Gonzales Clavijo, envoy of Henry VIII., of Castile, entered the city in 1404. He was not able himself to fix either the latitude or the longitude of Samarcand, but M. Struve, who was there on a scientific mission last year, has proved the latitude to be $39^{\circ} 38' 45''$, and the longitude $64^{\circ} 38' 12''$.

"Central Asia," by M. Pierre de Tchihatchef, Conseiller d'Etat, S.M. l'Empereur de Russie, attracted much interest and attention. The author first referred to the intended publication of a new, complete, and correct edition of Humboldt's *Asie Centrale*. Such a work would, at present, be peculiarly important and strikingly opportune, for it would dispel for ever the threatening clouds which, during so many years, were gathering on those regions as gloomy forebodings of a dreadful contest. While our knowledge of Central Asia remained scanty and vague, the mysterious country must have appeared, not only to the ignorant crowd, but also to many of the most enlightened and sagacious statesmen, as the natural battlefield where, sooner or later, England and Russia had to meet in a dogged, exterminating struggle. "The danger seemed so unavoidable and so urgent, that no expenses, no sacrifices were spared, in order to postpone the disastrous crisis. Now, thanks to the exertions of geographers, the ominous crisis, so positively prophesied and so unanimously feared, turned out to be nothing more than a fantastical dream; for nothing, surely, could be more fantastic, nothing more fitted to remind one of the *Thousand and One Nights*, than to see a large army with heavy artillery, not only hover like ghosts during two or three months over dense clouds and eternal snows, but even after such an exhausting gymnastic feat, descend into the country of the enemy, and defeat the English troops quietly and comfortably expecting their curious visitors." This, however, is precisely the fact, which must be admitted by the advocates of a Russian invasion of India; for M. de Tchihatchef says we possess numerous trustworthy documents which prove most positively that even in the very probable case of the whole of Turkestan becoming a Russian province—whatever might be the starting-point of the Russian army intended to reach the Punjab—no less than two, or perhaps even three, months would have to be spent amidst snowy, desert mountains, before such an army would be allowed to put its frost-bitten feet on English territory. M. de Tchihatchef admitted that amongst the advocates of Russian invasion there are men of deep science and unquestionable good faith; but they all start from two very arbitrary hypotheses, *viz.* that what has been done once may be performed again, and that what is now impossible may become possible. Alexander the Great and certain Mogul conquerors may have crossed the mountains and marched victoriously onward; but the conditions under which they performed these feats were widely different to those which would be imposed upon an invading Russian army. The Abyssinian expedition brilliantly proved that a European army might drag its ponderous artillery over large, snowy, mountainous tracts; but the result of that expedition might not have been so glorious had the army of resistance been composed of French, Russian, or Prussian soldiers, instead of those of Theo-

dore. M. de Tchihatchef declared the Russian invasion of India to be a bugbear; but intimated that both England and Russia have a peculiar mission in Central Asia, which can only be successfully carried out by a combination of their exertions, and by their placing their moral and material interests under the mighty safeguard of peace, mutual sympathy, religious toleration, and justice.

In the discussion which followed the reading of this remarkable paper, Lord Halifax said it was undeniable that the advance of Russia towards the northern frontier of India caused some uneasiness; but when he was Secretary of State he gave his attention to this important question, and came to the conclusion that the alarms which existed in many minds were utterly unfounded. These alarms, he believed, M. de Tchihatchef's paper would in a great measure dissipate. Lord Houghton was a little more cautious in expressing unqualified satisfaction at the advances of Russia, though he considered the objects of Russia to be similar to what our own have been, *viz.*—"in a certain degree to promote its own power, but in a greater degree to extend civilization."

Mr. Trelawney Saunders considered the question was not a military one, but one of commercial and administrative competition.

A paper "On the Encroachment of the Sea on Exmouth Warren" was next read by Mr. G. Peacock, and was followed by one, entitled "On the Kitai and Kara Kitai," by Dr. G. Oppert. The Kitai Dr. Oppert described as a people who once ruled over Central Asia and China, and who gave their name to Asia. He also said that the famous Prester John was Emperor of this people, who now live in a humble condition in the Russian Government of Derberd, and in the Siberian district of Ili.

The Section did not meet on Saturday in consequence of the excursion to Plymouth; and on Monday the proceedings commenced with a paper by Captain R. C. Mayne, R.N., on "Recent Surveys in the Straits of Magellan." Captain Mayne alluded to the history of the discovery of the Straits, and described their geographical position. He pointed out their use in avoiding the troublesome passage around Cape Horn; and gave some particulars respecting the size and appearance of the Patagonians and Fuegians. The former are not such giants as have been represented, their average height being from 5 feet 10 inches to 5 feet 11 inches, though he measured one man who was 6 feet 10½ inches high.

Admiral Sir Edward Belcher read a paper "On the Distribution of Heat on the Sea Surface throughout the Globe," and was followed by Mr. A. G. Findlay "On the supposed Influence of the Gulf-stream on the Climate of North-Western Europe." The author demurred to many of the theories that have been advanced on this subject, and accounted for the phenomena of our warm winter

climate as follows:—"The great belt of south-west winds called the Anti-trade, or Passage winds, passes over the North Atlantic throughout its breadth, and drives slowly the whole surface of the water to the northward of an easterly course or towards the shore of North-West Europe. From the particular configuration of the land, this north-west drift is allowed to pass into the Polar area. This south-west wind infuses into high latitudes the temperature and moisture of much lower parallels, and by its greater rate of travelling passes over the warmer water to the southward, and this brings to Exeter in one day the warmth of the centre of France. By its variation from westward or eastward of a southerly direction, we find all the variations or moisture which is induced by this wind passing over land or sea."

"On the Best Route to the North Pole," by Captain R. V. Hamilton, R.N., and "The Upper Amazons," by Mr. F. F. Searle, were the concluding papers of the day.

The Section met for the last time on Tuesday morning. "Cooper's Attempt to Cross from China to India" was read by Mr. Trelawney Saunders. Though the details of Mr. Cooper's adventures were very interesting, Mr. Saunders pointed out that he had been unable to contribute anything of value in a geographical point of view, and his enterprise was fruitless and unsuccessful through the jealousy and cupidity of the Chinese mandarins.

A lengthy and important paper on the "Trade Routes between Northern India and Central Asia" was next read by Mr. Douglas Forsyth. This distinguished member of the Indian Civil Service said that he had no geographical discoveries to make known, but he intimated that the work of applying to practical purposes the knowledge acquired by scientific men ought to receive some share of general approval. Having described the two great outlets for trade from Northern India, and given a history and description of the country north of the Himalayas, Mr. Forsyth showed that Central Asian trade is not a myth, as has been asserted, but is very valuable and capable of immense development.

Mr. Trelawney Saunders then read a paper "On the Himalayas and Central Asia," and explained that the difficulties in passing the mountains are not insurmountable to trade and intercourse. The vast countries beyond the Himalayas constitute the greatest pastoral region in the world; and as there is such a field of raw material, there would doubtless be found an equally important market for manufactured articles. In the discussion which followed the reading of these three papers, Sir Harry Verney, Sir Stafford Northcote, Dr. Thomson, and the President took part. Sir Harry Verney said our duty is to give every facility for the opening up of trading intercourse with Central Asia, but we should

not endeavour to obtain any monopoly, and should speak in unmistakable language to prevent the distrust of any other power. Sir Stafford Northcote deprecated the idea that our duties to commerce and civilization should be regarded in the nature of rivalry with Russia. We must consider the question as bearing on the interests of the great masses of people committed to our charge in India, and consider also that whatever is for the advantage of India must be for the advantage of adjacent peoples. We must be careful not to engage in any enterprises likely to bring us into collision with the frontier tribes, and must not put our arm out farther than we could draw it back again. Sir Stafford declared it to be for our interest, as far as possible, to surround our empire in India with independent, flourishing States, which would feel it to be their interest to be on good relations with us, and that their prosperity was bound up with ours.

A "Scheme for a Scientific Exploration of Australia," by Dr. G. Neumayer; a paper by Mr. W. P. Blanford "On Northern Abyssinia;" and one "On Raleigh's El Dorado," by Dr. C. Le Neve Foster, concluded a by no means unimportant or uninteresting, if not a brilliant, meeting.

MECHANICAL SCIENCE. (Section G.)

This Section met in St. John's Hospital, under the Presidency of Mr. C. W. Siemens, C.E., F.R.S., by whom a very excellent and instructive opening address was delivered. Including the Presidential address, the reports from committees, and papers from members, there were altogether twenty-five communications made to the Section, if we likewise include four papers which were taken as read at the last sitting of the Section. As Saturday was set apart for the excursion to Plymouth and Devonport, and as the subject of the Patent Laws naturally attracted the engineers to the Statistical Section on the ensuing Wednesday, the last day of the Exeter meeting, Section G had only four sittings—on Thursday, Friday, Monday, and Tuesday.

The President's address embraced some remarks on the somewhat hackneyed subject of technical education, and specially commended Mr. John Scott Russell's lately published volume treating on this subject. Almost as a matter of course, Mr. Siemens dwelt at some length on the system of Letters Patent, on which he can certainly speak as "one having authority." He put the question of the theory and practice of Letters Patent in a very clear light by the following brief statement. "According to modern views," he said, "a patent is a contract between the Commonwealth and an individual who has discovered a method, peculiar to himself, of accom-

plishing a result of general utility. The State, being interested to secure the information, and to induce the inventor to put his invention into practice, grants him the exclusive right of practising it, or of authorizing others to do so, for a limited number of years, in consideration of his making a full and sufficient description of the same. Unfortunately, this simple and equitable theory of the patent system is very imperfectly carried out, and is beset with various objectionable practices which render a patent sometimes an impediment to, rather than a furtherance of, applied science, and sometimes involve the author of an invention in endless legal contentions and disaster, instead of procuring for him the intended reward. These evils are so great and palpable that many persons, including men of undoubted sincerity and sound judgment on most subjects, advocate the entire abolition of the patent laws. They argue that the desire to publish the results of our mental labour suffices to ensure to the Commonwealth the possession of all new discoveries or inventions, and that justice might be done to meritorious inventors by giving them national rewards. This argument may hold good as regards a scientific discovery, where the labour bestowed is purely mental, and carries with it the pleasurable excitement peculiar to the exercise and advancement of science on the part of the devotee; but a practical invention has to be regarded as the result of a first conception, elaborated by experiments and their application to existing processes in the face of practical difficulties, of prejudice, and of various discouragements, involving, also, great expenditure of time and money, which no man can well afford to give away, nor can men of merit be expected to advocate their cause before the national tribunal of rewards, where, at best, only very narrow and imperfect views of the ultimate importance of a new invention would be taken, not to speak of the favouritism to which the doors would be thrown open. Practical men would undoubtedly prefer either to exercise their inventions in secret, where that is possible, or to desist from following up their ideas to the point of their practical realization."

Mr. Siemens also referred to Watt's invention, patented 100 years ago; to recent progress and prospective efforts in railway and telegraphic engineering; to the engineering progress in respect of offensive and defensive warfare; to the newest methods of making steel for constructive purposes; to Mr. Whitworth's experiments, the results of which seem likely to render the steam-hammer and rolling-mills obsolete in the process of forging steel; to scientific economy in generating heat from coal; and to the production of refrigeration at an extremely moderate expenditure of fuel and labour. On the motion of Mr. Bidder, a hearty vote of thanks was awarded to Mr. Siemens for his interesting, instructive, and very appropriate address.

At the first day's sitting there were read papers by Mr. Fairbairn, Col. H. Clerk, R.A., and Mr. R. Eaton. Mr. Fairbairn's was a "Further Report on the Mechanical Properties of Steel." It was very elaborate and highly statistical. A point of considerable importance in connection with the communication was the reliable details given regarding the properties of the Heaton steel. Mr. Fairbairn's experiments referred almost exclusively to the Heaton steel, and to the Barrow Company's hæmatite steel. The last-mentioned substance has very great "ductility combined with a tensile breaking-strain of from 32 to 40 tons per square inch. With these qualities," said Mr. Fairbairn, "I am informed that the proprietors are able to meet the requirements of a demand to the extent of 1000 to 1200 tons of steel per week, which, added to a weekly produce of 4500 tons of pig-iron, enables us to form some idea of the extent of a manufacture destined in all probability to become one of the most important and one of the largest in Great Britain."

The paper by Colonel Clerk, entitled "Description of the Hydraulic Buffers and Experiments on the Flow of Liquids through Small Orifices at High Velocities," gave rise to a very interesting discussion. The author of the paper being desirous of applying some method of checking the recoil of heavy guns, consulted Mr. Siemens about two years ago, and suggested magnetism as the form of force to be employed; but the "magnetic doctor," as Mr. Siemens has been styled, suggested hydropathic treatment rather than magnetic, and in Col. Clerk's hands it has proved to be most valuable, so valuable, indeed, that the hydraulic compressor or buffer invented by Col. Clerk is now being tried in a modified form by railway engineers. The buffer has been used on shore with guns up to 25 tons weight, and at sea with light guns of $1\frac{1}{2}$ cwt. and 8 cwt. in boats, and with 9-inch guns of 12 tons on board H.M.S. 'Prince Albert,' and in all cases with great success.

Mr. Eaton's paper was "On Certain Economical Improvements in obtaining Motive Power." It contained an account of a modification of the steam-engine recently made and brought into use in Nottingham by Mr. George Warsop, the son of an air-gun maker, born with aerial ideas, educated at a Sunday-school, and sent to work at ten years of age. Later in life he was a working mechanic in the employment of Ericsson, in New York, and had an opportunity of noting the weak points of that eminent engineer's air-engines, and profited by the experience gained. More recently Mr. Warsop has devised, in the words of Mr. Eaton, "a marvellously simple system of mechanism, which, as far as present experience goes, promises complete success by means which, happily for the cause of economy and progress, are compatible alike with physical science

and mechanical construction." The piece of mechanism is known as the Aëro-Steam Engine, and, as may be inferred from the name, the motive-power is a mixture of air and steam. Before a very decided opinion can be given regarding this invention, it will be requisite to wait for the results of the experiments which are in progress, or in prospect, by Professor Tyndall and others.

Professor W. J. M. Rankine, C.E., F.R.S., read two reports from committees of which he is a member. One was "On the Laws governing the Flow and Action of Water containing Solid Matter in Suspension," and the other was an "Interim Report from the Committee on Agricultural Machinery." It was stated that a full and satisfactory report on agricultural machinery would be ready for next year's meeting.

"On the Laws determining the Fracture of Materials when Sudden Changes of Thickness take place," formed the subject of a somewhat technical paper by Mr. F. J. Bramwell, C.E.; and Admiral Sir Edward Belcher communicated a paper "On a Navigable Floating Dock;" but the chief point of interest at Friday's sitting of the Section was the very elaborate paper "On the Channel Railway," giving an account of the method by which Mr. J. F. Bateman, C.E., and M. Rêvy, C.E., Vienna, propose to connect England and France. The paper was too long for us to make anything like an intelligible abstract of it. Suffice it to say that Messrs. Bateman and Rêvy's scheme embraces a cast-iron tube, thirteen feet in internal diameter and four inches thick, with additional strengthening in the way of ribs, flanges, and annular discs or diaphragms, and that railway trains are to be worked through this tube by pneumatic pressure. In an animated discussion which followed the reading of the paper, Messrs. Bidder (father and son), Vignoles, the President, and other gentlemen took part.

At Monday's sitting no fewer than four reports were read from committees, the reporters being Mr. L. E. Fletcher, C.E.; Mr. C. W. Merrifield, F.R.S.; Professor Rankine, and Mr. R. B. Grantham, C.E.; and the reports being, respectively: on Boiler Explosions; on the State of Knowledge of Stability and Sea-going Qualities of Ships; on the Analysis and Reduction of Observations in the Report of the Steamship Performance Committee, and on Sewage. The following are the conclusions arrived at by the Boiler Explosion Committee:—1. That a lamentable loss of life is annually caused by steam-boiler explosions, which urgently calls for public attention. 2. That these explosions, as a rule, are not accidental, but may be prevented by the exercise of "common knowledge and common care." 3. That the present investigations conducted by Coroners with regard to steam-boiler explosions are eminently unsatisfactory, and call for immediate improvement. 4. That Coroners

should, when conducting inquiries on boiler explosions, be instructed and empowered to avail themselves of competent engineering advice, so that the cause of every explosion may be fully investigated, while the information acquired should be widely circulated. 5. The committee entertain a sanguine hope that this course alone would do much towards the prevention of the present recurrence of steam-boiler explosions, without any further governmental action. The report was signed by Mr. Fairbairn, the Chairman of the committee. By way of supplement to the report, and for the purpose of raising a discussion, Mr. Fletcher submitted a short paper "On Government Action with regard to Boiler Explosions." The discussion took place on the following day, and it may be referred to at this stage. Mr. Alcock, Mr. Bramwell, Mr. Longridge, Captain Galton, Mr. Webster, Q.C., Professor Rankine, the President, and others took part in it, and all deprecated Government interference in the way of inspection. Various suggestions were made in reference to the stamping of boiler-plates by the makers; to the persons employed as boiler-tenters; to the qualifications of boiler-makers; and in reference to the way in which boiler inspection should be conducted. It was strongly urged by several of the speakers that efforts should be made to strengthen the hands of the Coroner, and render his court of inquiry a reality instead of a sham, and that persons using steam-boilers should be made responsible for the consequences caused by explosions. In the course of the discussion Captain Galton stated that he had induced the Government to place some hundreds of boilers under the inspection of the Association for Guaranteeing Steam-boilers against Explosion.

The report submitted by the Steamship Performance Committee was a very full and valuable paper, but notwithstanding its fulness it only claimed to be a *first* report, treating of only a portion of the subject, namely, the resistance which ships offer to propulsion, and to their behaviour in respect of rolling. The value of the report "On the Treatment and Utilization of Sewage" can scarcely be overrated. It had previously been submitted to the Chemical Section by Dr. B. H. Paul, who compiled it. Its value did not depend upon the opinions expressed by the Committee, inasmuch as they did not express any, but upon the facts which it brought together regarding the efforts at treatment and utilization of sewage both at home and abroad. Through the Home Office the Committee obtained information from Hamburg, Saxe-Coburg Gotha, Holland, Bavaria, Baden, Saxony, Prussia, Switzerland, Austria and Hungary, Belgium, Sweden, Denmark, Turkey, Greece, Russia, the United States of America, and Wurtemberg; and by means of schedules sent out to 338 local, sanitary, and sewer authorities, the committee obtained replies from 107 places to the queries contained in the schedules. Those queries referred to the population,

area, number of houses, and rateable value of the places applied to; the nature, source, and extent of the water-supply; the disposal of the excretal refuse; and to the total quantity and amount of the liquid sewage and its treatment. The committee is re-appointed, and therefore we may expect that next year's report will prove a valuable supplement to the one read at Exeter.

Some interesting facts were mentioned by Mr. Thomas Login, C.E., in his paper "On Roads and Railways in Northern India, as affected by the abrading and transporting power of Water." This paper was followed by one of great value from Mr. Joseph Whitworth, C.E., F.R.S. It was "On the Penetration of Armour-Plates with Long Shells having Large Bursting Charges, and fired obliquely," and was a sort of supplement to the paper read by Mr. Whitworth at the Norwich meeting last year. The author claimed that the experiments detailed in his paper showed that the Palliser projectiles failed to penetrate when striking at an angle, solely on account of the form of the head,—the Whitworth projectile, which resisted the shock, and did not break up, being deflected in precisely the same manner as the Palliser projectile which was shivered into fragments. Almost all the speakers who joined in the discussion excited by the paper, spoke very favourably of the flat-headed projectile, and urged that trials should be instituted with it by the Government.

Of the papers read at the last sitting of the Section, that by Mr. Thomas D. Barry "On the Utilization of Town Sewage" produced the greatest amount of discussion. It was not much else than a glorification of the ABC process as practised at Leamington. Neither the paper nor the resulting discussion did much good in the way of throwing light on this vexed question.

A rather abstruse paper by Mr. Latimer Clark "On the Birmingham Wire Gauge" was read in the absence of the author. One by Mr. S. A. Varley was of much more general interest: it was "On a New System of Communication between Guards and Passengers on Railways." Mr. Varley's system is one of great ingenuity and is thoroughly efficient. At the request of the Board of Trade it was fitted up in a train running daily from London to Wolverhampton—a distance of 250 miles. The train was started from all stations at which it stopped by means of the apparatus, and its working reported by the guards in their daily reports. The apparatus was tested twenty-two times, and its performance, as shown by those reports, was marked by the most unvarying regularity. It is desirable to mention that Mr. Varley's system is an electrical one, but it does not require any electrical knowledge in the person working it. In closing the discussion upon the paper, the

President remarked that his own idea was that the electrical system was the only one which would work satisfactorily.

Mr. E. Froude read a paper, in which he detailed some curious and successful efforts to clean the internal surface of the Torquay water-main, an iron pipe fourteen miles long. In the year 1864 the delivery of water from the main was reduced to 320 gallons per minute, or only about one-half the amount due to the size and fall of the pipe. After trying several expedients for scraping off the oxidized material in the pipe by hydraulic pressure, Mr. Froude was able, in April of this year, to increase the discharge to 660 gallons per minute. To keep the pipe in a satisfactory condition it is necessary to scrape it at least once a-year. The cost of scraping is very trifling, and the whole fourteen miles can be done at one time.

In concluding this brief notice of the proceedings in the Mechanical Section, we are bound to admit that a fair amount of interesting work was done; but when we have said this we have almost said all. Of this we feel assured, that the British Association Meeting of 1869 will not be marked in the calendar with a "red letter" in so far as mechanical science is concerned. The meeting of 1870 in Liverpool ought to bring forth something that will be much more worthy of being put on record.

Quarterly List of Publications received for Review.

1. The Scenery of England and Wales; its Character and Origin :
being an attempt to trace the Nature of the Geological Causes,
especially Denudation, by which the Physical Features of the
Country have been produced. *With 86 Woodcuts.* By D.
Mackintosh, F.G.S. *Longmans.*
2. Wrought-Iron Bridges and Roofs. By W. Cawthorne Unwin,
B.Sc., &c. *E. & F. N. Spon.*
3. Entozoa : being a Supplement to the Introduction to the Study of
Helminthology. By T. S. Cobbold, M.D., F.R.S.
Groombridge & Sons.
4. Sound : a Course of Eight Lectures delivered at the Royal Insti-
tution of Great Britain. By John Tyndall, LL.D., F.R.S.
Second Edition. *Longmans.*
5. The Substitution of Similars : the True Principle of Reasoning.
By W. Stanley Jevons, M.A., London. *Macmillan & Co.*
6. The Transactions of the Woolhope Naturalists' Field Club.
Illustrated with Photographs, Lithographs, and Woodcuts.
Times Office, Hereford.
7. The True Theory of the Earth. By Research.
Bell & Bradfute.
8. The Birds of Sherwood Forest. By W. J. Sterland.
L. Reeve & Co.
9. The Geometry of the Circle and Mathematics. By James Smith.
Simpkin, Marshall, & Co.
10. Latitude and Declination Tables. By Major-Gen. R. Shortrede.
Strahan & Co.
11. Abolition of Patents : Recent Discussions in the United Kingdom
and on the Continent. *Longmans.*
12. Practice with Science. Vol. II. A Series of Agricultural Papers.
Longmans.
13. How to keep the Clock Right, by Observations of the Fixed Stars
with a small fixed Telescope. By T. Warner. *Williams & Norgate.*

PAMPHLETS AND PERIODICALS.

- The Economic Geology of Devonshire and Cornwall in 1868. By
R. Hunt, F.R.S. *Clowes & Sons.*
- On Geological Dynamics. By Sir William Thomson, LL.D., F.R.S.
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On some Fossils found in the Eophyton Sandstone at Lugnas in Sweden. By J. G. O. Linnarsson.

Figures of Characteristic British Fossils. By W. H. Baily.

Van Voorst.

Notes on the Flora of Manbhúm. By V. Ball, B.A.

On the Copper Mines of Singhbhúm.—(Geological Survey of India.)
Same Author.

On Hydrofluoric Acid. By G. Gore, F.R.S.

Öfversigt af Kongl: Vetenskaps-Akademiens Förhandlingar.

Stockholm: P. A. Norstedt & Söner.

The Thames Gold Fields, Province of Auckland.—(Geological Survey of New Zealand.)

Smithsonian Miscellaneous Collections—

Land and Fresh-water Shells of North America. By W. G. Binney and T. Bland.

Ditto ditto Catalogue of the Orthoptera of North America.
By S. H. Scudder.

Report of the National Academy of Sciences.—(Smithsonian Report.)

Observations on the Genus Unio. By Isaac Lea, LL.D., Philadelphia.

Descriptions of Twelve New Species of Unionidæ, &c. Same Author.

Memoirs of the Peabody Academy of Science.

Revision of the large Stylated Fossorial Crickets. By S. H. Scudder.

Salem, Mass.

Description of a New Instantaneous Wet Collodion Process, &c. By Thomas Sutton, B.A.

J. W. Green, Paternoster Row.

Colorado (U.S.A.): its History, Geography, and Mining. By R. Old.

London: Brit. and Colorado Mining Bureau.

A Guide to the Study of Insects. By A. S. Packard, jun., M D.

Salem: Essex Institute.

Arithmetical Exercises for Chemical Students. By C. J. Woodward, B.Sc.

Ira Connell, or the Evils of Vaccination.

London: F. Pitman.

Despotism.

Longmans.

Quarterly Notes on Books.

Longmans.

The Dietetic Reformer and Vegetarian Messenger.

Pitman.

Revue Bibliographique Universelle.

Paris.

The American Naturalist.

Van Nostrand's Engineering.

The Chicago Medical Times.

The Westminster.

The Geological Magazine.

Scientific Opinion.

The Popular Science Review.

Cosmos. Edited by Victor Meunier.

Paris.

PROCEEDINGS OF LEARNED SOCIETIES, &c.

The Journal of the Ethnological Society.

Trübner & Co.

Proceedings of the Cotteswold Naturalists' Field Club for 1868.

First Annual Report of the Bournemouth Meteorological Society.

First Annual Report of the Trustees of the Peabody Academy of
Science.

Salem, Mass.

Proceedings of the Royal Institution.

„ „ Royal Society.

„ „ Royal Astronomical Society.

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